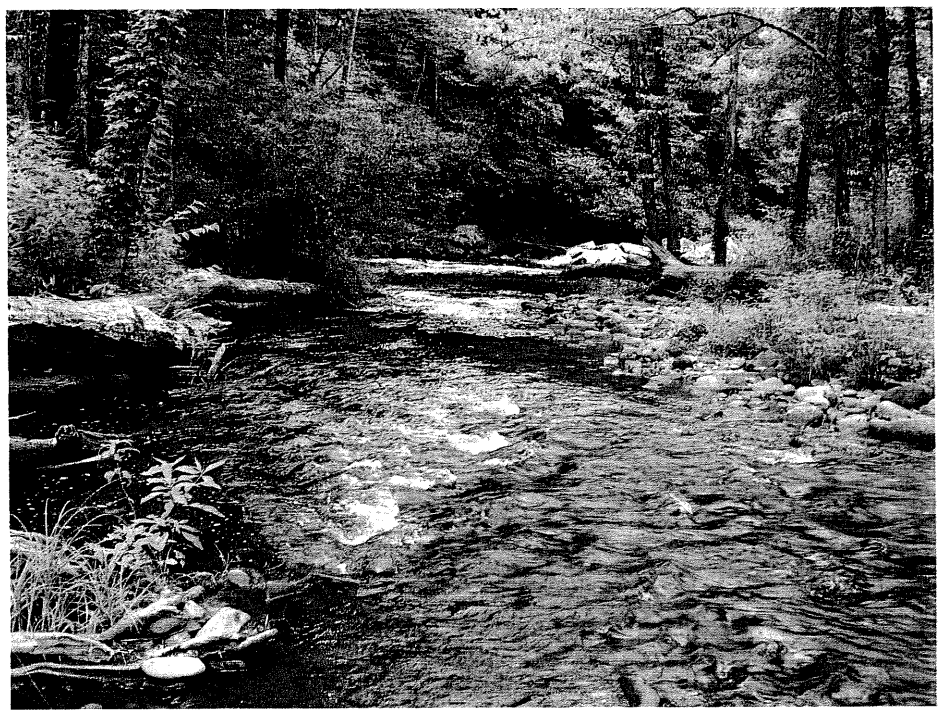
STANDARD OPERATING PROCEDURES
FOR
BENTHIC MACROINVERTEBRATES

BIOLOGICAL ASSESSMENT UNIT

JULY 2006



NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT
and NATURAL RESOURCES
Division of Water Quality
Environmental Sciences Section

NCDENR

July 26, 2006

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This report has been approved for release

Jimmie Overton
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Date: July 26, 2006

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BENTHIC MACROINVERTEBRATES

INTRODUCTION

Benthic macroinvertebrates, especially aquatic insects, are associated with the substrates of streams, rivers and lakes. The Biological Assessment Unit uses aquatic macroinvertebrates as one type of indicator of biological integrity in streams and rivers. A large number of sites are sampled each year during basinwide sampling and special studies, and resulting information is used to document both spatial and temporal changes in water quality, and to complement water chemistry analyses. Although bioassessments are useful for identifying biological impairments, they do not identify the causes of impairment. Linking biological effects with their causes if particularly complex when multiple stressors impact a waterbody (USEPA 2000).

There are several reasons for using biological surveys in monitoring water quality. Conventional water quality surveys do not integrate fluctuations in water quality between sampling periods. Therefore, short-term critical events may often be missed. The biota, especially benthic macroinvertebrates, reflect both long and short term conditions. Since many species in a macroinvertebrate community have life cycles of a year or more, the effects of a short-term pollutant will generally not be overcome until the following generation appears.

Macroinvertebrates are useful biological monitors because they are found in all aquatic environments, are less mobile than many other groups of organisms, and are of a size which makes them easily collectable. Moreover, chemical and physical analysis for a complex mixture of pollutants is generally not feasible. The aquatic biota, however, show responses to a wide array of potential pollutants, including those with synergistic or antagonistic effects. Additionally, the use of benthic macroinvertebrates has been shown to be a cost-effective monitoring tool (Lenat 1988). The sedentary nature of the benthos ensures that exposure to a pollutant or stress reliably denotes local conditions, and allows for comparison of sites that are in close proximity (Engel and Voshell 2002).

Analysis of faunal assemblages is one way to detect water quality problems (Rosenberg et al 1986). Different kinds of stress will often produce different benthic macroinvertebrate communities. For example, the taxa associated with organic loading (and low dissolved oxygen) are well known. More recent studies have begun to identify the biological impacts of sedimentation and toxic stress (Burton, 1991, Waters 1995, Bode and Simpson 1982, Clements 1994).

Identification at, or near, the species level is desirable for many genera (Cranston 1990, Resh and Unzicker 1975). Such genera may include *Polypedilum*, *Cricotopus*, *Hydropsyche*, *Ephemerella*, *Stenonema, Acentrella* and *Baetis*. Recent work by Lenat and Resh (2001) has shown the benefits of precise taxonomy for both pollution monitoring and conservation biology. Species-level taxonomy is more effective than family-level taxonomy in detecting both the best and worst streams within any given ecoregion. Precise taxonomy is also required to locate the rare species in potential HQW/ORW waters. Tolerant species will usually become dominant only in polluted systems. Allowances must also be made for stream size, geographic location and seasonality. Flow conditions are also related to the relative impacts due to point and nonpoint sources. High flows often increase the impact of nonpoint sources, while reducing the impacts of point sources. The reverse is often true for low flows. Drought conditions can have a more long-term impact on the benthic community than floods. The presence of rare or endangered species is often associated with good water quality.

It is the purpose of this manual to provide details on routine or standard operating procedures of the Biological Assessment Unit (BAU) of the Division of Water Quality (DWQ) for the collection and analysis of freshwater benthic macroinvertebrate data. Estuarine monitoring is no longer conducted by BAU staff. Consistency in data collection and analysis is the cornerstone for evaluating biological integrity. The procedures provided in this manual are a synthesis of widely used methodologies and methodologies developed from the experience of personnel within the unit. These have been shown to provide repeatable and useful data for water quality evaluation.

This manual will be reviewed regularly and revised as necessary. The prior approved version of this manual was dated July 2003. All current employees and new employees within the unit will be provided with this manual to serve as a guideline of the unit's activities, methods, and procedures. Revisions of this manual will be provided to each employee and it will be the responsibility of the employee to keep his or her manual current.

The standard operating procedures (SOP) and quality control procedures (QC) in this manual will be the basis for all benthic monitoring by BAU staff in the waters of North Carolina, and the subsequent data provided in memos and reports. Deviations from these procedures for unusual sampling situations shall be documented in the appropriate report or memo.

SAFETY PROGRAM

The Biological Assessment Unit is required to sample throughout North Carolina at times and places where medical facilities may not be readily available. It is imperative that all employees are instructed in and follow safety precautions when using equipment and hazardous materials. The Environmental Sciences Branch has a Safety Committee which is responsible for maintenance and development of current safety procedures. The Committee also maintains the safety standard operating procedures document, with which all personnel should be familiar.

Sampling conditions are the primary safety factor to be considered for field work. If any field conditions, such as high flows or thunderstorms, raise the question of whether a sample can be safely collected, then decisions should always be made with the safety of personnel of prime concern. This same concern for safety of staff must be of primary importance when scheduling the amount of time to be spent in the field. Long days combined with strenuous effort increase the probability of accidents occurring. Sample days longer than 12 hours will not be approved, unless an emergency requires a longer day. Safety first must always be the rule.

With the increasing prevalence of Lyme disease and West Nile virus, it is the responsibility of all employees to maximize protection against these insect borne diseases. This should include the use of insect repellants, and a thorough check for ticks after every day in the field.

All vehicles are provided with first aid kits, which should be used for minor injuries. Employees should promptly report on-the-job accidents to their supervisor. All employees must be familiar with and follow procedures and deadlines for all Workmen's Compensation claims. If an accident occurs during field operations, the first responsibility of the team leader is to get first aid or emergency treatment for the injured employee; their second responsibility is to promptly notify their supervisor. The Safety Committee maintains a written record of accidents.

STUDY PLANS

All investigations conducted by the Biological Assessment Unit will follow a written study plan including but not limited to the following:

Introduction - Will identify the nature and history of the area being investigated and the person or agency requesting the study.

Objectives - The purpose of the investigation and expected accomplishments.

Sampling Location Selection - Locating sampling points is of extreme importance in the initiation of benthic macroinvertebrate monitoring. The variables in watersheds are many and should be considered in as much detail as possible before sites are selected to monitor any body of water. Land use (i.e., urban, rural, forested, agricultural, industrial) should be considered when locating sample sites, because man-made activities significantly affect the amount of sedimentation, nutrients, and organic or inorganic compounds entering a given segment of a river, lake or stream. The location of permitted dischargers should be reviewed, using the database provided by the NPDES Unit of DWQ. Discussion of the proposed study with regional office personnel can also provide additional information useful for determining sampling locations. Pre-study planning of this nature will enhance data interpretation once collections and analysis begin. "No Trespassing" signs must be respected, and may prevent access to some sites.

Methodology - Sampling techniques should be listed with reference to those described in this manual. Any deviation from these standard methods must be noted and described.

Analytical Requirements - All parameters to be collected, and analyses that will be required, should be noted.

Logistics - Shall include estimates of manpower requirements, equipment needed, time requirements, methods of sample transport to laboratories, etc. The study plan must be submitted and approved by the employee's supervisor prior to the investigation.

A study is complete when a written memo is sent to the appropriate level of management (typically the Environmental Sciences Branch head) within DWQ and approved by that level. Each memo written for a study should contain an **Introduction or Background** section, **Sampling Sites**, **Methods**, **Results and Discussion,** and **Summary or Recommendations**, along with any figures needed to allow a reader to easily locate the sampling sites. When the report or memo is approved, a Biological Assessment Unit File Number is assigned. Finally, the report or memo is filed in a Projects File that is organized by river basin and subbasin.

SAMPLE COLLECTION

Sampling Requirements

Most of the sampling methodologies described in this manual require that freshwater streams or rivers be wadeable for efficient data collection. High water conditions severely impair sampling efficiency by making some critical habitats inaccessible. An underestimate of taxa richness due to high flows may lead to an incorrect assessment of water quality. **If high water makes sampling conditions marginal, it is better to return to the site during a more appropriate flow regime**.

Drought conditions can also play a major role in altering the composition of the benthic fauna. Every effort should be made in parts of the state that are susceptible to flow interruption during droughts to to be sure that flow has been continuous prior to sampling. Flowing water in a stream immediately following a period of rain may mask antecedent conditions. Prior flow conditions can be difficult to determine, especially in smaller streams, but USGS flow data from nearby streams should be used to make the best determination of prior flow conditions. Sampling should be delayed, if possible, when prior flow conditions have been extreme-either high or low. Streams less than 1 meter wide should not be sampled. The rule of thumb is that if you can jump across it, you shouldn't sample it.

Before any sampling trip is begun, the trip leader will have an approved study plan or list of sites for basinwide sampling. An itinerary will be planned to maximize collection efficiency. Regional Office personnel must be advised before any sampling trip as to where and when work will be done in their region. The trip leader should also use the Internet to check stream stage height from the closest USGS gage station before traveling to the site.

An experienced benthic biologist trained and skilled in field benthic sampling methods and organism identification must be present for all sample collections. New or inexperienced personnel (eg, staff from other Units of DWQ) can be used as team members, if close supervision is provided by the experienced biologist during sample collection, during sample picking (look through trays again), and during visuals.

Our Endangered Species Permit is renewed annually and requires that **permission be obtained from the Wildlife Resources Commission (WRC) before any sampling be conducted in areas with endangered species**. The back of the permit lists all such areas. If permission is granted, the WRC has also asked that a minimal amount of walking in the stream be done in reaches with endangered mussels, to reduce the possibility of inadvertently crushing the mussels.

Field Procedures

Samples are collected using the techniques described in this manual. All samples are field picked as described under Standard Qualitative Method. The number of samples collected is dependent on the type of methodology used. Sampling equipment is simple to use, durable and portable.

Samples are labeled before leaving the site with waterbody name, station location, collection card number, initials of collectors, and date of collection. A gage reading is taken if a gage is present or gage height (stream stage) taken from the USGS web site immediately upon return to the office. Stream stage and stream flow (cfs) should be added to the collection card and entered in the comments section of the database, along with notes about range of gage heights that should be targeted for adequate sample collection. Photographs of the site must be taken. Water temperature, pH, conductivity and dissolved oxygen measurements will be taken and recorded on the collection card. All meters must be calibrated in the lab and a lab calibration form filled out, before the meters are taken into the field. Data from an

uncalibrated meter should not be entered into the benthos database. Calibration instructions for all meters can be found in the lab in a notebook with calibration forms.

A site sketch should be made, showing any unique habitats, for all basin assessment locations that do not have site sketches already in the Basin Site Notebooks. This sketch should include enough detail that subsequent samplers can return to the same sampling location every five years.

A habitat assessment form (Appendix 2) should be filled out for all collections. Directions are given on the form. In most areas, it is obvious whether the Mountain/Piedmont or the Coastal Plain habitat form should be used. In some transition areas, however, a field decision must be made as to which form to use. If the stream is naturally rocky with a natural riffle-pool sequence then the Mt/P habitat form should be used, even if the Level IV ecoregion map puts the site in the coastal plain. The reverse is true for a naturally sandy, low gradient stream located on the map in the Piedmont, but near a coastal plain ecoregion.

The benthos **collection card** (Appendix II) must be filled out. Field observations should include:

Immediate watershed - type of land use, extent of disturbed land, any floodplain deposition of sediment, any evidence of stream widening and/or filling in, presence of upstream tributaries or dams (including beaver dams), evidence of recent water level changes such as leaf packs out of water, submerged terrestrial vegetation, and sediment on vegetation above water level, any livestock with access to stream, any point sources, any unique habitats.

Substrate - **Two** collectors must make independent estimates of substrate percentages and the independent and average values recorded on the collection card. Also note embedded substrate (interstitial spaces filled in with sand), any atypical habitats such as bridge rubble, large bedrock or other rock outcrops or unusual geological formations, abrupt changes in slope, presence of normal riffle-pool sequence (riffles spaced at intervals equal to 5-7 times stream width), any large areas of unstable coarse sand or movement of bedload material, and amount of substrate covered with *Aufwuchs* or silt.

Width - Since DWQ studies have suggested that stream width is a primary factor in determining expected taxa richness, especially in unimpacted headwater streams, the measurement of wetted stream width should be done as accurately as possible. Pacing off a width measurement on the bridge is useful for large rivers. Reflective safety vests should be worn whenever working on bridges. A tape measure could be used to measure smaller streams at two points that are representative of the area sampled. If an actual measurement is not taken, then **two** independent estimates of stream width should be recorded and the average noted, to the nearest whole number. A width estimate of 6.5 meters (average of 6 and 7) implies a degree of accuracy not found with visual estimates. Any unusual characteristics, such as a braided channel in coastal areas, should be noted and recorded.

Water - Look for color, odor (especially sewage and/or chlorine), foaming, algal mats, and oil sheen.

Benthic Community - Note presence of organisms not usually collected such as bryozoa, sponges, mussel shells. Note dominant organisms and any that are very abundant. Note if diversity is limited to banks and snags above the effects of sediment scour. Give overall impression of site.

All samples are transported in state-owned vehicles to the Biological Assessment Unit in Raleigh. Vehicles are locked when unsupervised, and sample custody is maintained at all times by field collectors.

A fixed number of benthic samples are processed at each location. The sampling techniques outlined here usually take 4-6 person hours, i.e. 1 1/2 - 2 hours per site with three collectors for the standard qualitative method, and 45 minutes to 1 hour for the EPT method using three collectors. However, the time necessary to collect at a station may vary depending on factors such as stream size (a large river takes more time than collecting in a small stream) or flow conditions. A collection team can do a minimum of 3-4 stations per day. Seven stations in close proximity is the record for BAU.

SAMPLING METHODOLOGIES

Overview

Four different macroinvertebrate collection methods are used by the Biological Assessment Unit. The first method is a standard qualitative method which can be used to assign water quality ratings to most wadeable flowing streams and rivers in North Carolina. This methodology is applicable for most between-site and/or between-date comparisons, and should be used for all evaluations of impaired streams (those on the state 303d list), that are large enough to rate.

The second collection method is the EPT method, an abbreviated version of the regular qualitative technique. This technique is used to quickly determine between-site differences in water quality. It is particularly useful for:

Watershed or basin assessment studies with large numbers of sites, or emergency sampling where it is desirable to rapidly assess the effect of spills, unusual discharges, etc.

Although the EPT method is a more rapid sampling technique, there are situations where the EPT method may provide too little information for an adequate assessment of water quality. Such situations include areas with naturally low EPT richness and areas where the abundance of more tolerant groups must be assessed. If a biotic index must be calculated, then an EPT sample is inappropriate. In order to decide which is the most appropriate sampling technique, an investigator must consider the number of sites to be sampled, what kind of existing data might be used for comparisons, how soon a report will be required, and what kind of between-site differences must be detected.

A third sampling methodology, that was tested between this revision of the SOP Manual and the last revision, is called the Qual 5 or Qual 4 method. This uses the same collection techniques as the abbreviated EPT version, with the addition of one rock/log wash for the Qual 5, but all organisms are picked from the samples. This method should only be used for very small streams that will likely have few EPT taxa, but where data are needed to assess differences in the benthic community.

The fourth collection method is used for swamp streams that stop flowing in summer months, but have visible flow during late winter. A boat sampling technique for sampling nonwadeable freshwater rivers is an adaptation of the standard qualitative method.

Standard Qualitative Method

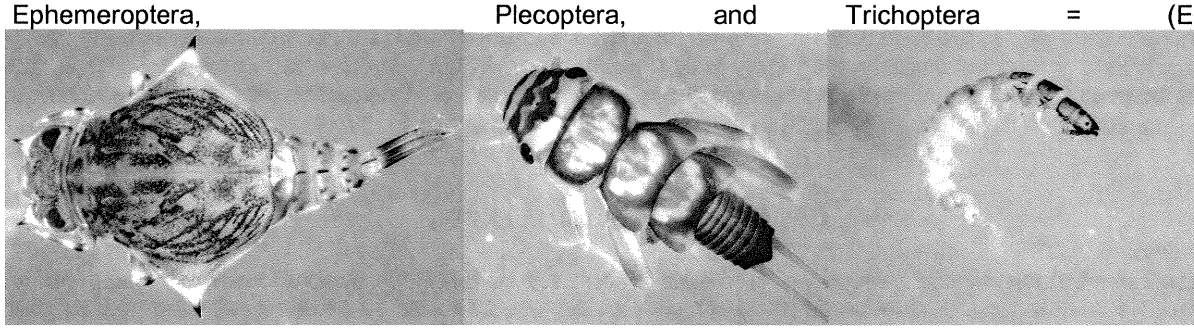
This collection technique consists of two kick net samples (kicks), three sweep-net samples (sweeps), one leaf-pack sample, two fine-mesh rock and/or log wash samples, one sand sample, and visual collections. Invertebrates are separated from the rest of the sample in the field ("picked") using forceps and white plastic trays, and preserved in glass vials containing 95% ethanol.

Organisms are picked roughly in proportion to their abundance, but no attempt is made to remove all organisms. If an organism can be reliably identified as a single taxon in the field (an example would be *Isonychia*), then no more than 10 individuals need to be collected. A detailed discussion is given below and in Lenat (1988). Some organisms are not picked, even if found in the samples. These include colonial species (Bryozoa, Porifera), Nematoda, Collembola, semiaquatic Coleoptera such as Chrysomelidae, and all Hemiptera except Naucoridae, Belostomatidae, Corixidae and Nepidae. These are not picked either because abundance is difficult to quantify or because they are most often found on the water surface or on the banks and are not truly benthic. The hemipteran families that are included can spend long periods below the water surface.

EPT Method

The EPT technique is a modification of the qualitative collection. The collection and analysis time has been decreased in two ways. First, collections focus on a subset of the benthic community:

Ephemeroptera, Plecoptera, and Trichoptera = (EPT).



These orders usually include the most intolerant species of benthos. Field notes also are made concerning the abundance of other groups, especially any pollution indicator species. Secondly, the

number of collections is decreased from 10 samples (in standard qualitative collections) to only 4 samples: 1 Kick, 1 Sweep, 1 Leaf-pack and "visuals". A comparison of the results between the qualitative and the EPT method is given in Eaton and Lenat (1991).

Qual 4

The Qual 4, as the name implies, is an abbreviation of the standard qualitative method, where all organisms are picked. These methods were designed to be used **only** in small streams, orginally defined as those that are less than 4 meters wide, now defined as having a DA $\leq$ 3 square miles. In these methods, 4 samples are collected: one Kick, one Sweep, one Leaf-pack, and "visuals". All organisms are picked. The Watershed and Assessment Restoration Program (WARP) began collecting many samples from small streams in impaired watersheds in 2000. This program began using the Qual 4 method. After collecting this data from small streams, especially in impaired watersheds, it was decided that an abbreviated method was needed that should enhance collection of a representative sample of the chironomid population, and a rock/log wash was added. A Qual 5 method was tested as a possible efficient way to provide enough data from small streams to eventually lead to a way to determine water quality impairments or assign bioclassifications. Data analysis indicated that the wash provided few new taxa and little change in minimum rating. The Qual 5 method was dropped in July 2003, and the Qual 4 method was retained for small streams only. In 2005 and 2006 many Qual 4 samples were collected in small reference watersheds to help develop criteria for evaluating small streams. Only limited data analysis of those sample has been done.

Swamp Method

The Biological Assessment Unit defines "swamp streams" as those streams that are within the coastal plain ecoregion and that normally have no visible flow during a part of the year. This low flow period usually occurs during summer months, but flowing water should be present in swamp streams during the winter months. Sampling during winter, high flow periods provides the best opportunity for detecting differences in communities from what is natural, and only winter (February to early March) benthos data can be used when evaluating swamp streams. The swamp stream must have visible flow in this winter period, with flow comparable to a coastal plain stream that would have acceptable flow for sampling in summer. Swamp streams with pH values of 4 or lower cannot be rated, and even those below 4.5 are difficult to evaluate.

The swamp sampling method utilizes a variety of collection techniques to inventory the macroinvertebrate fauna at a site. A total of nine sweep samples (one series of three by each field team member) are collected from each of the following habitat types: macrophytes, root mats/undercut banks, and detritus deposits. If one of these habitat types is not present, a sweep from one of the other habitats is substituted. A sweep for the swamp method is defined as the area that can be reached from a given standing location. Each sweep should be emptied into a tub before the next sweep is collected, to prevent clogging of the net, but all three sweeps can be combined in the same tub. Three log/debris washes are also collected. Visual collections are the final technique used at each site.

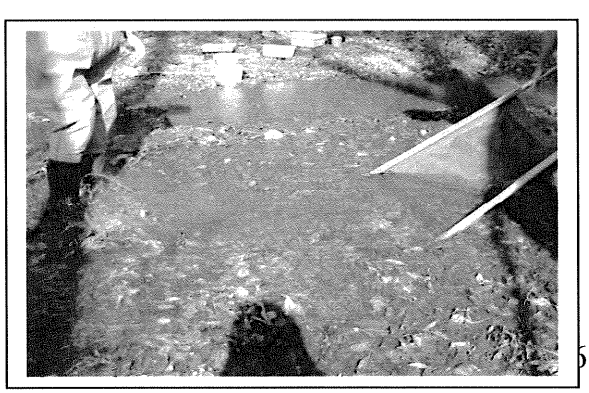
Samples are picked on site as described under the Standard Qualitative method above. The primary output for this sampling method is a taxa list with an indication of relative abundance (Rare, Common, Abundant) for each taxon.

FRESHWATER SAMPLING TECHNIQUES

Standard Qualitative Samples

Kick Net

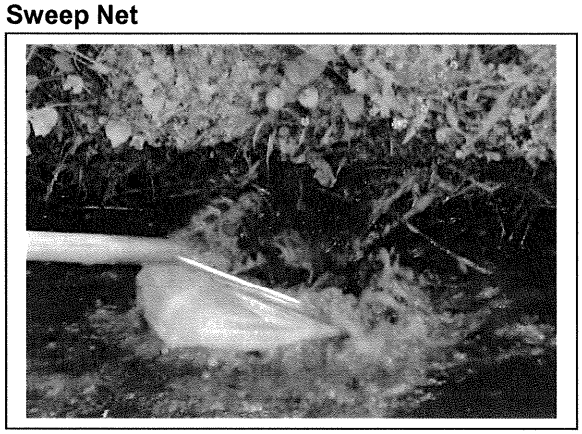
A kick net is an easily constructed and versatile sampling device. It consists of a double layer of flexible nylon door or window screening held in place between two halves of a wooden pole using wood screws. The screening is reinforced with denim along all edges and has lead weights sewn into the bottom edge. The screening can be sewn onto the denim using a heavy duty sewing machine.



The net is positioned upright on the stream bed, while the area upstream is physically disrupted using feet and/or hands. The debris and organisms in the kick net are then washed down into a sieve bucket with a US Standard No. 30 mesh (0.600 mm opening) bottom, and larger leaves and debris are removed. DWQ biologists have found that this technique gives very consistent results. If too coarse a mesh is used for the kick net, many animals will not be retained. If too fine a mesh is employed, the net clogs easily and washout becomes a problem. The double layer of screening works well in this respect.

Two kicks are taken from riffle areas. The two samples should be collected from areas of differing current speed. In very small streams, or in sandy areas lacking riffles, kicks should be taken from root masses, snags, or bank areas. All types of benthic macroinvertebrates are collected by this sampling device, but emphasis is placed on Ephemeroptera, Plecoptera and Trichoptera.

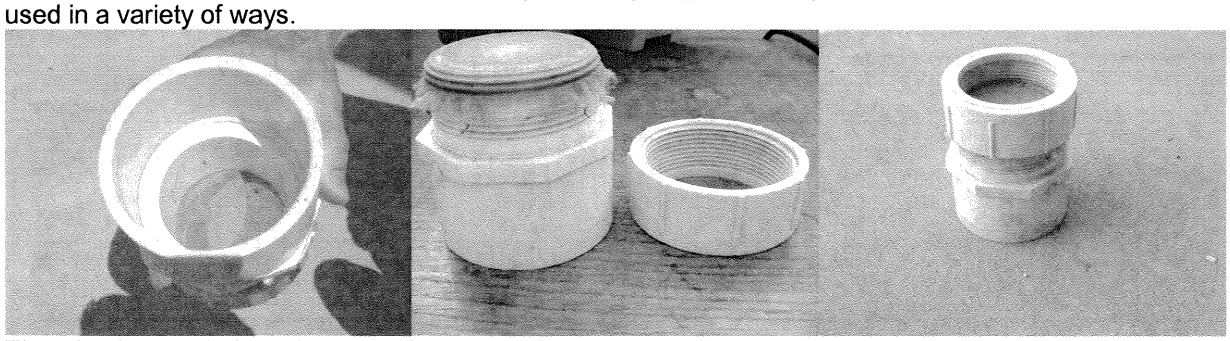
Sweep Net



A long-handled triangular sweep net is another versatile sampling device. Three samples are taken by physically disrupting an area and then vigorously sweeping through the disturbed area. Sweeps are usually taken from bank areas, including mud banks and root masses, and macrophyte beds. Bank samples are particularly important for the collection of "edge" species which prefer low current environments. Look for Chironomini (red chironomids), Oligochaeta, Odonata, mobile cased Trichoptera, *Sialis*, Crustacea, and certain Ephemeroptera. A sweep net also can be used to sample gravel riffle areas where stone-cased Trichoptera may be abundant.

Fine-Mesh Sampler

Since the kick and sweep nets utilize a relatively coarse mesh size, an alternate sampling technique was devised to sample the smaller invertebrates (especially the Chironomidae). The resulting sampler is known as a "chironomid-getter". Fine nitex mesh (300 microns) is placed between four inch PVC pipe fittings that are designed to screw together. The exact dimensions are not critical, but the cylinder should be able to fit inside another container, usually a slightly larger, round plastic container. This device can be used in a variety of ways.



The simplest technique is to wash down rocks or logs in a large plastic tub partially filled with water. Rocks are selected which have visible growths of periphyton, *Podostemum*, or moss. Any large

particulate material (leaves, etc.) is washed down and discarded. A single composite sample can be made from several (usually 10-15) rocks and/or logs. The material remaining in the tub is poured through the fine mesh sampler and the water allowed to drain out completely.

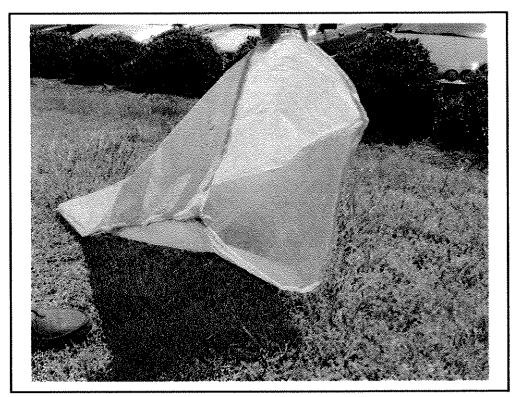
The residue is preserved in 95% ethanol. This is accomplished by placing the fine mesh sampler into another container (6 cup size round plastic food storage container works well) which is half filled with alcohol.

The sample is allowed to sit for several minutes, pulled out of the alcohol, and then backwashed into a picking tray. This method of field preservation requires only a small amount of alcohol, and it may be reused several times. Usually 2-3 of the fine mesh samplers are used, so that one may be soaking while another is being picked. Take care to rinse samplers between sites.

Field preservation makes small chironomids and oligochaetes more visible, and easier to pick up with forceps. This technique is also good for fast moving organisms such as baetid mayflies or amphipods, or small grazing taxa such as hydroptilid caddisflies. The "pour-and-preserve" technique also can be used in conjunction with other sampling methods. For example, the elutriate from a kick or sweep sample can be processed in this manner. It is also used in conjunction with sand samples (see below).

Sand Sample

Sandy habitats often contain a distinct fauna, but extraction of this fauna by means of dredge-type sampling can be tedious. Sandy substrates (in areas with definite flow, if possible) are sampled with a large bag constructed of fine mesh (300 microns) nitex netting. It can be quickly constructed from a one meter square piece of netting, folded in half and sewn together on the opposite side and the bottom. This bag is employed like a Surber sampler, but the lack of a rigid frame allows for easy storage when folded.



The bag is held (open) near the substrate with the left foot holding the bag on the sand, and the sand is vigorously disturbed by the collector's other hand or foot. The material collected (a lot of sand and a few organisms) is emptied into a large plastic container half-filled with water. A "stir and pour" elutriation technique is used in conjunction with the fine mesh sampler. After field preservation, the elutriate is picked, looking especially for small Chironomidae (*Cryptochironomus*, *Robackia*, *Rheosmittia*, *Harnischia* group, *Polypedilum*), oligochaetes, and Baetidae. The remaining sand can be picked quickly for large or heavy organisms such as Gomphidae or *Corbicula*.

Leaf-Pack Sample

Leaf-packs, sticks and small logs are washed down in a sieve bucket with a U.S. Standard No. 30 sieve (0.600 mm openings) bottom, and then discarded. Generally, three to four leaf packs are collected from rocks or snags in fast current areas. The best leaf packs consist of older leaves (not freshly fallen) that have begun to decay. Piles of leaves in pool areas should not be collected. Leaf-pack and small log samples are particularly useful in large sandy rivers. In such habitats, many of the species are confined to

"snags" (Benke et al. 1984, Neuswanger et al. 1982). Look for "shredders", especially Tipulidae, Plecoptera, and Trichoptera.

Visual Search

Visual inspection of large rocks and logs (the larger, the better) often adds to the species list. Large rocks and logs are a preferred microhabitat because of their stability during floods. Always look in a number of different areas (not just riffles). Rocks and logs in pools often yield additional species, as this habitat is not well sampled by either kicks or sweeps.

The top of rocks is a specialized microhabitat with a number of characteristic taxa. Both the caddisflies, *Psychomyia* and *Leucotrichia,* and the lepidoptera family Pyralidae, build retreats on the top of rocks. These are often made more visible by lightly washing off any silt which has accumulated on the top of the rock. Stone cased caddisflies, such as *Glossosoma*, *Agapetus*, *Ceraclea*, and *Goera* can also be found on the top or sides of rocks. Decaying logs should be picked apart to look for chironomids, and many taxa can be found under loose bark. Rocks near the shore (in negligible current) will harbor taxa such as *Stenacron* and *Pycnopsyche*, and leaves near the shore may be the primary habitat for some Gastropoda.

Certain caddisflies (*Nyctiophylax* and related genera) select crevices in rocks or logs, often along the edge, and cover them over with silk strands. The silk becomes covered with silt and periphyton and is hard to see. There is usually a faint opening on each end of this retreat. If the tip of forceps is inserted into one opening, the larvae usually will come out the other opening. Microcaddisflies make small (2-4 millimeters) cases found attached to rocks and logs, usually on the top or along an edge. The sides of rocks are the best place to look for the caddisflies *Neophylax*, *Psilotreta* and *Agarodes*.

Polycentropodid caddisflies build funnel-shaped silken retreats (up to six inches in length) in areas of relatively slow current. Out of water, the case collapses and resembles a gelatinous brown glob. The larvae will often crawl out if left out of the water for several minutes. It's a good idea to recheck some logs during visuals for these caddisflies.

In sandy coastal plain rivers, look for a log that is in an area of faster current, with some portion raised above the substrate. This is a good place to look for hydropsychids and other filter-feeders. The net may be the only visible evidence of these organisms, and they must be dug out of their retreats with forceps. Aquatic macrophytes and sponges are other habitats to be closely examined.

Mussel species can be obtained by careful visual inspection of the bottom. A mussel search should be conducted if dead shells are evident along the shore; look for midden heaps resulting from the feeding of muskrats and other vertebrates. However, only live specimens should be added to the species list. During periods of receding water levels, many species will move to deeper water, leaving a visible "track". The bases of aquatic weeds (especially water willow) may contain many mussel species and must be searched by hand. If possible, mussels should be identified in the field and returned (alive) to the stream. If sampling in an area with known populations of endangered or threatened mussels, any live mussels should be photographed or sketched and returned to the stream.

Approximately 10 minutes is allocated for these visual searches. In general, look for attached cases of Trichoptera, for Turbellaria (flatworms), Coleoptera (beetles), Odonata (dragonflies, especially on large logs), Gastropoda (snails), Hirudinea (leeches) and Megaloptera.

Boat Sampling

Most collections are in wadable streams, but there are some locations where a boat is required. These are usually large coastal plain rivers, including the lower sections of the Alligator, Chowan, Meherrin, Neuse, Pasquotank, Perquimans, Roanoke, Tar, South, Black, Waccamaw, Wiccacon, Northeast Cape Fear and Cape Fear rivers. In such habitats, petite ponar dredge sampling replaces kick-net samples, but all other standard qualitative collection techniques are still useable. Most of these localities have little or no visible current, but it is important to record in the field notes how much current is present, especially after heavy rainfalls. Coastal B criteria are used to evaluate such sampling sites.

The standard boat method still aims at a total of 10 composite samples per site. Efficiency is maximized by leaving 1-2 people on shore to collect sweeps, epifaunal collections, visuals, part of leaf-pack/debris sample, while the boat samplers collect petite ponar samples, at least part of leaf-pack/debris sample, part of one epifaunal wash,and part of visuals (logs in the current). When the shore area is very steep, some sweeps may be collected from the boat, although this can be less effective than wading.

Petite ponars will be collected at 3 locations between midstream and the bank, with three replicates at each locations (a total of 9 samples). Sandy samples should be elutriated and processed through a fine-mesh sampler (chironomid getter). Samples that are mainly organic can be picked live, but some portion should be processed through the fine-mesh sampler. If possible, the 3 locations should include a variety of depths, with at least one location in the 2-3 meter range. This may not be possible in all locations; but it is preferable to utilize a variety of depths. No petite ponars should be collected from the area normally sampled during shore work, i.e., <2 meters in depth. The petite ponar should be lowered slowly, so as to avoid disturbance of surface sediments. The shallow collections are often good habitat for *Hexagenia* and *Phylocentropus*. Collection card notes should include some record of the depths sampled and the general substrate composition at each location. Large clams (*Corbicula*, *Rangia*) can be identified, recorded on the collection card, and discarded.

Sweeps Three sweeps will be collected from bank habitats at each site, sampling as much of the edge habitat as possible. If aquatic macrophytes are present, then these should be sampled in one of the three sweeps. Other areas to be included include roots and areas of debris. Many kinds of invertebrates are collected this way, but look for cased Trichoptera (*Triaenodes*, *Oecetis*, etc.) and Baetidae.

Leaf packs/Debris (1 composite sample) Leaves and other large particulate organic matter are to be rinsed in a wash bucket. It will often be necessary to use the boat to get to habitats where leaves accumulate. Where leaf packs are not present, then sticks, logs, and aquatic plants may be sampled.

Epifaunal collections (2 composite samples) Macrophytes and well-colonized logs (both in the current and along the shore) should be washed down and processed through the fine-mesh sampler. As usual, this is aimed at getting a good sample of the midge community, but a wide variety of other taxa also will be collected. Collections which have very few numbers of midges should be repeated, as the epifaunal community can be very patchy. If the epifaunal community is very sparse, it is important that it is known that this pattern is related to water quality/habitat quality, and is not a function of sampling technique.

Visuals (treated as 1 composite sample) A fairly large proportion of the EPT fauna often is collected during the visual portion of sampling. Areas to be covered during visuals include:

Macrophytes, especially those with floating leaves. Look for those with some evidence of breakage and/or decomposition. Often the plants on the outside of a macrophyte patch (away from the shore) will have more types of macroinvertebrates. Look for leaf-mining midges and beetle larvae, Hydroptilidae (several genera), snails, and limpets.

Logs along the shore. Look for evidence of long-term colonization, especially periphyton and sponge growths. If the water level has risen recently, it is necessary to search for logs in deeper waters. This often means kicking up logs with your feet, unless you want to get very wet. Look for leeches (especially under bark, Polycentropodidae (several genera), small sand-cased Trichoptera (*Ceraclea*, *Oecetis*, *Phylocentropus*), *Pycnopsyche*, Heptageniidae, wood-mining midges, and snails. It is crucial that team members can recognize polycentropodid retreats.

Logs in the current. This part of the visuals usually must be conducted from the boat, and should be continued until several well-colonized logs have been found. You should be looking for epifaunal habitat that is out in the current (or where current might be at higher flows), but is large enough not to be washed downstream. This often means dragging into the boat some very large logs; if you can lift it up easily, it is probably too small. Colonization by Hydropsychidae is a good sign, but also look for Heptageniidae, Baetidae, Plecoptera (esp. *Acroneuria* and *Neoperla*), and sand-cased Trichoptera.

LABORATORY TECHNIQUES AND DATA INTERPRETATION

When a sample is returned to the laboratory for analysis, the person identifying the sample will combine all vials collected from a site into one petri dish for identification. All organisms in the sample are then identified to the lowest possible taxonomic level, recorded on a Benthic Macroinvertebrate Lab Sheet (Appendix II), and tabulated as Rare=1 (1-2 specimens), Common=3 (3-9 specimens) or Abundant=10 ($\geq$10 specimens). Most organisms may be identified using only a dissecting microscope, but Oligochaeta, Chironomidae and some mayfly structures must be mounted on glass slides and identified with a compound microscope. Following identification, samples are labeled and stored for an indefinite time period. All molluscs and crayfish are saved, labelled, and sent to the museum collections next door. Lab sheets and all associated information are also filed by river basins.

After the sample is identified and the lab sheet is complete, all taxonomic data, along with data from the benthos collection card, is entered by biologists into a benthos database utilizing the software application Fourth Dimension (4D). After the data is entered, it is checked for coding or relative abundance errors. It is imperative that consistent coding be used when entering data in the fields for waterbody, sample type, ecoregion and bioclassification. Please use the most current coding memo for the correct codes. When the data is saved, total taxa richness, EPT taxa richness, Biotic Index value for the sample, EPT Biotic Index value and EPT abundance are automatically calculated. A species list for one or many samples can be retrieved using this system.

The ultimate result of a benthos sample is a bioclassification for the sample. Bioclassifications used by BAU are Excellent, Good, Good/Fair, Fair or Poor for standard qualitative and EPT samples. This bioclassification is automatically calculated in 4D, unless the sample is outside the summer period, from a small stream, or from a swamp stream. Any seasonal corrections are made manually (outside the database) after all taxa in a sample are entered into the database. The bioclassification is entered manually based on the corrected values and notes about corrections are made in the comments section for each sample.

The Qual 5 or Qual 4 method was used only for very small streams for which no criteria have yet been developed. For the Qual 5 method, the additional rock/log wash was kept separate from the four other composites for all 2002 samples. This allowed for the potential assignment of a minimum rating using EPT taxa richness (based on piedmont or mountain criteria for EPT samples applied to the wash excluded sample, which is the same as an EPT sample). Only EPT taxa richness values were used to determine impairment. A Not Impaired rating is given if the stream would receive a bioclassification of Good-Fair or better using DWQ EPT criteria developed for larger streams. Small streams that would have a minimum bioclassification of Fair or Poor continue to be Not Rated.

The final swamp stream criteria use a three bioclassification approach for evaluation rather than the five classes used for flowing streams because of the higher natural variability found in swamp streams. This variability makes it more difficult to evaluate minor changes in the benthic community. The final bioclassifications or stress categories for swamp streams are Natural, Moderate, and Severe, and also include habitat evaluation.

A complete list of all benthic macroinvertebrates collected (BINDEX) is maintained in the 4D database, or in an Access database. The BINDEX list contains the taxa code, the species name, order, family, tolerance value (an index based on the pollution tolerance of each taxa), and feeding type of each taxa. This list is given in Appendix 1 for all taxa that have been assigned a tolerance value.

EPT Criteria

The simplest method of data analysis is the tabulation of species richness. Species richness is the simplest measure of biological diversity (Larsen and Herlihy 1998). The association of good water quality

with high species (or taxa) richness has been thoroughly documented. Increasing levels of pollution gradually eliminate the more sensitive species, leading to lower and lower species richness.

Total taxa richness (S or ST) and taxa richness for Ephemeroptera + Plecoptera + Trichoptera (EPT S or SEPT) are calculated and EPT S is one metric used to assign a biological classification. The bioclassification or rating primarily reflects the influence of chemical pollutants. The effects of sediment are not assessed as well by taxa richness analysis, because the multihabitat sampling technique allows finding suitable habitats which remain above the level where scour or sediment deposition are having the most impact. Bioclassification criteria for EPT taxa richness values for three major ecoregions have been developed. For EPT samples, the criteria below,are the only metric used.

EPT TAXA RICHNESS CRITERIA FOR EPT SAMPLES

	Mountain	Piedmont	Coastal Plain (CA)
Excellent	>35	>27	>23
Good	28-35	21-27	18-23
Good-Fair	19-27	14-20	12-17
Fair	11-18	7-13	6-11
Poor	0-10	0-6	0-5

For standard qualitative samples, the EPT criteria shown here were historically used to directly assign bioclassifications, but now are not used directly because new criteria using borderline values were developed in 1995. (See Derivation of Final Bioclassification for Standard Qualitative Samples)

Historical EPT Criteria for Standard Qualitative

	Mountain	Piedmont	Coastal Plain (CA)
Excellent	>41	>31	>27
Good	32-41	24-31	21-27
Good-Fair	22-31	16-23	14-20
Fair	12-21	8-15	7-13
Poor	0-11	0-7	0-6

It should be noted that although most coastal plain samples use the above criteria, it has been found that large, deep, slow-flowing rivers have different benthic communities and need different criteria. These are discussed under Coastal B River criteria below. The Coastal Plain criteria above only apply to streams that have visible flow throughout the entire year (also called Coastal A streams). Swamp streams and coastal plain streams that stop flowing for portions of the year are now being evaluated using a different set of criteria (see below).

Seasonality Corrections

Bioclassifications are assigned from the EPT taxa richness values, based on the expected values for summer (June-September) collections. However, expected EPT taxa richness values will vary seasonally, and adjustments should be made to all non-summer collections. Seasonal studies indicate winter/spring increases in Plecoptera. Occasionally there are minima in Trichoptera during early spring and/or fall. This is one of the most station-specific patterns. DWQ sampling indicates that expected seasonal patterns for EPT taxa richness are not the same for all North Carolina streams. Until a better understanding of how these patterns vary geographically is derived, site-specific adjustments should be made:

The standard correction will be to subtract winter/spring Plecoptera, as this is found most often to be all that is needed. This correction must be noted in the 4D database in the comments section. If resources allow, it is preferred for non-summer collections to resample a nearby reference site, (as similar as possible in size and substrate type to the study site) that has prior summer data. Use this site to derive the appropriate seasonal correction, by comparing the summer data with the seasonal data to establish "normal" EPT values using comparable flow regimes and evaluations of taxa richness for each order. If non-summer values appear high, then subtract winter/spring Plecoptera, or subtract winter/spring Plecoptera + Ephemeroptera (especially for April and May samples).

All seasonal corrections should be made before using EPT values to assign bioclassifications. Review of reports within the unit will be used to maintain consistency within the unit for seasonal corrections.

Biotic Index Criteria

The Biological Assessment Unit had historically (1983-1990) assigned water quality ratings (= bioclassifications) based on EPT taxa richness alone or in combination with total taxa richness. The sole use of these taxa richness values to produce bioclassifications, however, made interpretation of some data very difficult. EPT taxa richness values must often be adjusted to account for collection method, stream size, seasonal changes, and ecoregion. For this reason, a North Carolina Biotic Index (NCBI) was

derived as another (independent) method of bioclassification to support water quality assessments (Lenat 1993). This index is similar to the Hilsenhoff Biotic Index (Hilsenhoff, 1987) with tolerance values derived from the NC database. Biotic indices may be calculated for both standard qualitative samples (NCBI or BI) or EPT samples (BIEPT), based on a 0-10 scale, where 0 represents the best water quality and 10 represents the worst. Only the BI values are used to produce a final site classification; the BIEPT values are only intended to aid in the interpretation of data.

The Biotic Index for a sample is a summary measure of the tolerance values of organisms found in the sample, relative to their abundance.

$$\text{Biotic Index (BI)} = \frac{\text{Sum}(TV_i)(n_i)}{N}$$

TV_i = ith taxa's tolerance value
n_i = ith taxa's abundance value (1, 3 or 10)
N = sum of all abundance values

Classification criteria for biotic index values were derived using the existing data base in 1991 by examining average biotic index values for each combination of bioclassification (based on EPT taxa richness), ecoregion and season. At that time a 0-5 scale was used for NCBI values. In 1992, the scale and associated criteria were expanded to 0-10 and tolerance values were recalculated using the database of samples collected to that time. A re-evaluation of tolerance values was done in early 1994. New Biotic Index values for all samples in the database were calculated. This revision led to the conclusion that separate criteria are needed for the mountain, piedmont and coastal plain (Coastal A) ecoregions. It also indicated that different seasonal corrections for fall, winter and spring are needed for these regions. These are the original criteria before borderline values were derived.

	Biotic Index*		
	Mt	P	CA
Excellent	<4.05	<5.19	<5.47
Good	4.06-4.88	5.19-5.78	5.47-6.05
Good-Fair	4.89-5.74	5.79-6.48	6.06-6.72
Fair	5.75-7.00	6.49-7.48	6.73-7.73
Poor	>7.00	>7.48	>7.73

* Historical use only

Occasional problems have been observed with Biotic Index value use:

1. BI and BIEPT may not measure impacts that are largely due to sediment, especially if measurements are conducted after a period of scour when sediment-tolerant species ("stable-sand" community) have not yet been established, or chironomids are sparse. In this instance, there may be a change in habitat quality, but no change in water quality. Similar communities will be found both above and below the source of sediment, but abundances will be sharply reduced in the sediment-impacted area. Both taxa richness and abundance values will be lower at impacted sites. For sites where such habitat changes are the primary cause of stress, the biotic index rating should be used with caution and discussion of results should clearly note the influence of sediment and flow.

2. In some intermediate piedmont/mountain regions, there is the problem of trying to decide which set of criteria should be used. The biotic index should be reviewed carefully at such sites to reduce the possibility of inappropriate criteria being used.

3. The BIEPT, and to some extent the BI, produce very low numbers in some high altitude mountain streams. This problem is immediately evident when control site values are so low that substantial increases do not result in a change in bioclassification. The BIEPT can be used to support other data, give site rankings and an assessment of damage if there are large between-site differences.

4. BIEPT values have little meaning when EPT N is very low (<30). In these cases, the EPT taxa could be mainly drift organisms from upstream, with no development of tolerant taxa at the stressed site. BI values also may not reflect additional impact if the control site is highly stressed, especially if it is rated as Poor. A typical example of this is when urban runoff impacts an upstream site.

Derivation of Final Bioclassification for Standard Qualitative Samples

For most mountain, piedmont and coastal plain (Coastal A) streams, equal weight should be given to both the NC Biotic Index value and EPT taxa richness value in assigning bioclassifications. Exceptions are

detailed in the preceding paragraphs. For these metrics, bioclassifications are assigned from the following scores:

Excellent: 5 Good: 4 Good-Fair: 3 Fair: 2 Poor: 1

"Borderline" values are assigned near half-step values (1.4. 2.6, etc.) and are defined as boundary EPT values ±1 (except coastal plain), and boundary biotic index values ±0.05. The two ratings are then averaged together, and rounded up or down to produce the final classification. The exception to this is discussed below and occurs when the EPT and BI score differ by exactly one.

The following table should be used to determine the scores for EPT taxa richness values and Biotic Index values for all standard qualitative (Full Scale) samples after seasonal corrections are made:

Score	BI Values			EPT Values		
	Mt	P	CA	MT	P	CA
5	<4.00	<5.14	<5.42	>43	>33	>29
4.6	4.00-4.04	5.14-5.18	5.42-5.46	42-43	32-33	28
4.4	4.05-4.09	5.19-5.23	5.47-5.51	40-41	30-31	27
4	4.10-4.83	5.24-5.73	5.52-6.00	34-39	26-29	22-26
3.6	4.84-4.88	5.74-5.78	6.01-6.05	32-33	24-25	21
3.4	4.89-4.93	5.79-5.83	6.06-6.10	30-31	22-23	20
3	4.94-5.69	5.84-6.43	6.11-6.67	24-29	18-21	15-19
2.6	5.70-5.74	6.44-6.48	6.68-6.72	22-23	16-17	14
2.4	5.75-5.79	6.49-6.53	6.73-6.77	20-21	14-15	13
2	5.80-6.95	6.54-7.43	6.78-7.68	14-19	10-13	8-12
1.6	6.96-7.00	7.44-7.48	7.69-7.73	12-13	8-9	7
1.4	7.01-7.05	7.49-7.53	7.74-7.79	10-11	6-7	6
1	>7.05	>7.53	>7.79	0-9	0-5	0-5

Biotic Index corrections for non-summer data:
Summer = Jun-Sep, Fall = Oct-Nov, Winter = Dec-Feb, Spring = Mar-May

	Fall	Winter	Spring
Mountain Correction	+0.4	+0.5	+0.5
Piedmont Correction	+0.1	+0.1	+0.2
Coastal A Correction	+0.2	+0.2	+0.3

EPT N Criteria for Rounding Decisions

The Biological Assessment Unit has in prior years (1983-1996) used EPT abundance (EPT N) values in evaluating water quality impacts without formal quantification of criteria. EPT abundance is the sum of the abundance values for all EPT taxa in a sample, where Rare = 1, Common = 3, and Abundant = 10. EPT N allows differentiation of situations where intolerant groups are simply present from situations where healthier (more abundant) populations exist in a stream. One example is a stressed site that is a short distance downstream of a much cleaner site. There could be continual drift colonization of the downstream site, but most EPT taxa should remain rare. EPT N will illustrate changes between these two sites more clearly than a simple count of EPT taxa.

EPT N, however, also might be expected to vary depending on flow, season, and normal sampling variability. For this reason, a slightly different approach relative to prior DWQ criteria development is used here to determine rounding criteria using EPT abundance. Normally, the suggested criteria would be derived by calculating the mean EPT N for each bioclassification, and then establishing the criteria values as half-way between these means. Instead, the means and standard deviations were calculated for each bioclassification in three ecoregions. The criteria, therefore, include most potential sources of variation. Seasonal variation was relatively low, and effect of stream width determined to be minor. EPT abundance is highest in the mountains and least in the coastal plain. Expected ranges for each bioclassification (+/- one standard deviation (SD)) show little overlap for areas of poorer water quality, especially the Fair and Poor bioclassifications. There is greatest overlap for the Good and Excellent categories in the piedmont and coastal plain.

The rounding approach is applied only when the BI and the EPT scoring differ by exactly one bioclassification, producing a final score midway between two ratings: 1.5, 2.5, 3.5, or 4.5. When trying

to decide between two bioclassifications, use the EPT abundance value criteria below (derived from mean for the higher bioclassification minus one SD), and round down if the EPT N is less than the value and round up if it is equal to or above the value.

Example: When comparing data from a Piedmont stream, and the BI score = 5, but the EPT score = 4. Round down (to Good) if EPT N < 135.

Rounding Criteria: Round down if EPT N < criterion, otherwise round up.

Bioclassification (Score)	MT	P	CA
Excellent (5) vs. Good (4)	191	135	108
Good(4) vs. Good-Fair (3)	125	103	91
Good-Fair (3) vs. Fair (2)	85	71	46
Fair (2) vs. Poor (1)	45	38	18

High Quality Small Mountain Stream Correction Factors

Correction factors have been developed for small high quality mountain streams where data have shown that EPT taxa richness values are reduced by factors other than water quality. Low productivity in such streams are often due to their pristine nature. A series of EPT surveys of mountain streams of different widths in the same unimpacted watershed in 1991 indicated a size correction factor of x1.45 for undisturbed mountain streams 1-2 meters in width or with drainage area less than about 1 square mile. A size correction factor of x1.25 is suggested for undisturbed streams 3-4 meters in width or with drainage area less than 3.5 square miles. The size correction for EPT taxa richness is made after any seasonal corrections are made. The EPT criteria values are used to determine the bioclassification after the correction is made. Because the original study was based on EPT samples, it is valid only for EPT samples.

Example: Undisturbed stream with drainage area of 0.7 square miles has EPT value of 18. Corrected value is 18 x 1.45 = 26, which is compared to EPT sample criteria values.

Other Small Streams (Qual 4 Method)

The Biological Assessment Unit has attempted to find similar unimpacted watersheds in the piedmont where size versus EPT studies could be conducted. It was not possible to find watersheds large enough to do the same studies as had been done in the mountains. Analysis of the data indicated that streams 3 meters or less in width should not be rated, if they are in disturbed watersheds in either the mountain or the piedmont. In August 2001 the decision was made to rate these small streams as Not Impaired if they would be given at least a Good-Fair bioclassification using the criteria derived for larger streams. Sites that would be at least Fair or Poor are given the bioclassification Not Rated. Because this is a minimum rating, it would be inappropriate for such sites to be put on the impaired streams list without further data evaluation to discern if the community present is influenced more by stream size or watershed impacts.

These small streams may be sampled because of special requests, and analysis of the community differences can and should be used to determine best professional judgement about impacts. Studies are underway to evaluate using drainage area (with a threshold of $\leq$ 3 square miles for when a Qual 4 sample should be collected) rather than stream width to decide when standard criteria should or should not be applied. It is possible that different drainage area thresholds will be used for mountain and piedmont streams. Small stream evaluation problems have not been found in the coastal plain, because small streams there typically have no flow for part of the year and are either not sampled, or are sampled using swamp methods.

Most small streams not in high quality mountain watersheds have been sampled using either the Qual 4 or the prior Qual 5 sampling method. For two years the rock/log wash was kept separate from the rest of the Qual 5 sample (=Qual 4 sample), and in 2003 a comparison of this Qual 4 vs Qual 5 data was made that indicated little additional information was provided by the extra wash. Until that comparison was made Qual 5 samples were not assigned a bioclassification, but differences in benthic communities were compared to assess impacts. Based on the Qual 4 vs Qual 5 data evaluation, in July 2003 all Qual 5 samples were assigned either a Not Impaired or Not Rated bioclassification using EPT criteria for larger streams. The Qual 5 method was dropped in July 2003, and only Qual 4 or EPT samples should now be collected from small streams (DA $\leq$ 3 square miles).

Coastal B Rivers Criteria
Coastal B rivers are here defined as waters in the coastal plain that are deep (nonwadeable) with little or no visible current under normal or low flow conditions and that have freshwater. Other characteristics may include open canopy, low pH, and low DO. These waters require a boat for sampling. The major rivers that are considered Coastal B were listed previously under Boat Sampling.

The Biological Assessment Unit has limited data on Coastal B rivers and has had a difficult time getting more data. Criteria have been developed based only on EPT taxa richness, though using biotic index values and total taxa richness values were also evaluated. The criteria that are presented here will continue to be evaluated, and any bioclassifications derived from them should be considered tentative and not used for use support decisions.

Bioclassification	EPT S
Excellent	>11
Good	9-11
Good-Fair	6-8
Fair	3-5
Poor	< 3

Swamp Stream Criteria
Preliminary criteria for swamp streams were developed in 1996 and tested in 1997 that used a combination of macroinvertebrate, fish and habitat data. It was difficult, however, to relate fish community information to either water quality or habitat quality and fish were difficult to sample in larger swamps with braided channels. For these reasons, only macroinvertebrate and habitat data were used to further develop swamp stream criteria. The preliminary rating system also put all swamp streams into a single category. Six years of swamp sampling suggested that both stream pH and channel type (braided or not-which must be entered into the data base) have major effects on the macroinvertebrate community, so the next investigation of swamp streams focused on examining the effect of these two variables on swamp stream benthos. Studies in both 1997 and 1998 were focused on an attempt to establish reference conditions for swamps. Learning from these initial sampling attempts, swamps streams were grouped along several physical and chemical gradients, specifically channel type, soil characteristics, and pH. Further revisions (1999-2002) indicated that criteria also must be developed for different ecoregions of North Carolina. When possible, these swamp regions coincide with the North Carolina Level IV ecoregions.

Continuing basinwide studies through 2002 sampled swamp streams through the entire North Carolina coastal plain, including the Pasquotank, Chowan, Roanoke, Tar, Neuse, Cape Fear, Lumber and White Oak basins. Criteria development was complicated by the effects of hurricanes and tropical storms, by the effects of severe drought, and by the high natural variability found in swamp streams. Despite these complications, the basinwide sampling provided enough data to finalize the swamp stream criteria. An academic panel was formed in December 2002 to review these swamp stream criteria. This panel recommended these swamp stream criteria be used to assign bioclassifications. They indicated that swamp stream criteria could be used on systems with severe hydrologic modifications (channelized streams, man-made canals), despite some concerns by BAU staff. Final criteria were approved in March 2003 for three bioclassifications or stress categories: Natural, Moderate, and Severe.

There are currently six swamp regions (Figure 1), although region D does not include sampleable streams. Ecoregion designations are taken from the Level IV ecoregions of North Carolina. Many of the swamp regions follow Level IV ecoregion boundaries, but were independently derived. The exception is the Carolina Flatwoods ecoregion, which has been subdivided into 3 swamp regions.

1. Region D. Region D is the outermost coastal area, extending northward from Carteret County in two ecoregions: the Chesapeake-Pamlico Lowlands and Tidal Marshes ecoregion (63b) and the Nonriverine Swamps and Peatlands ecoregion (63c). This area has many wetlands, but few flowing streams. No swamp streams have been located in this area.

2. Region C. Region C lies to the east of the Suffolk Scarp, within the Chesapeake-Pamlico Lowlands and Tidal Marshes ecoregion (63b). Sampleable swamp streams have been located only in the Pasquotank River basin. No undisturbed catchments exist in this area, but Deep Creek was the best stream sampled by DWQ. EPT taxa are rare or absent in these swamp streams, although they may be present in the larger rivers and low-salinity estuaries.

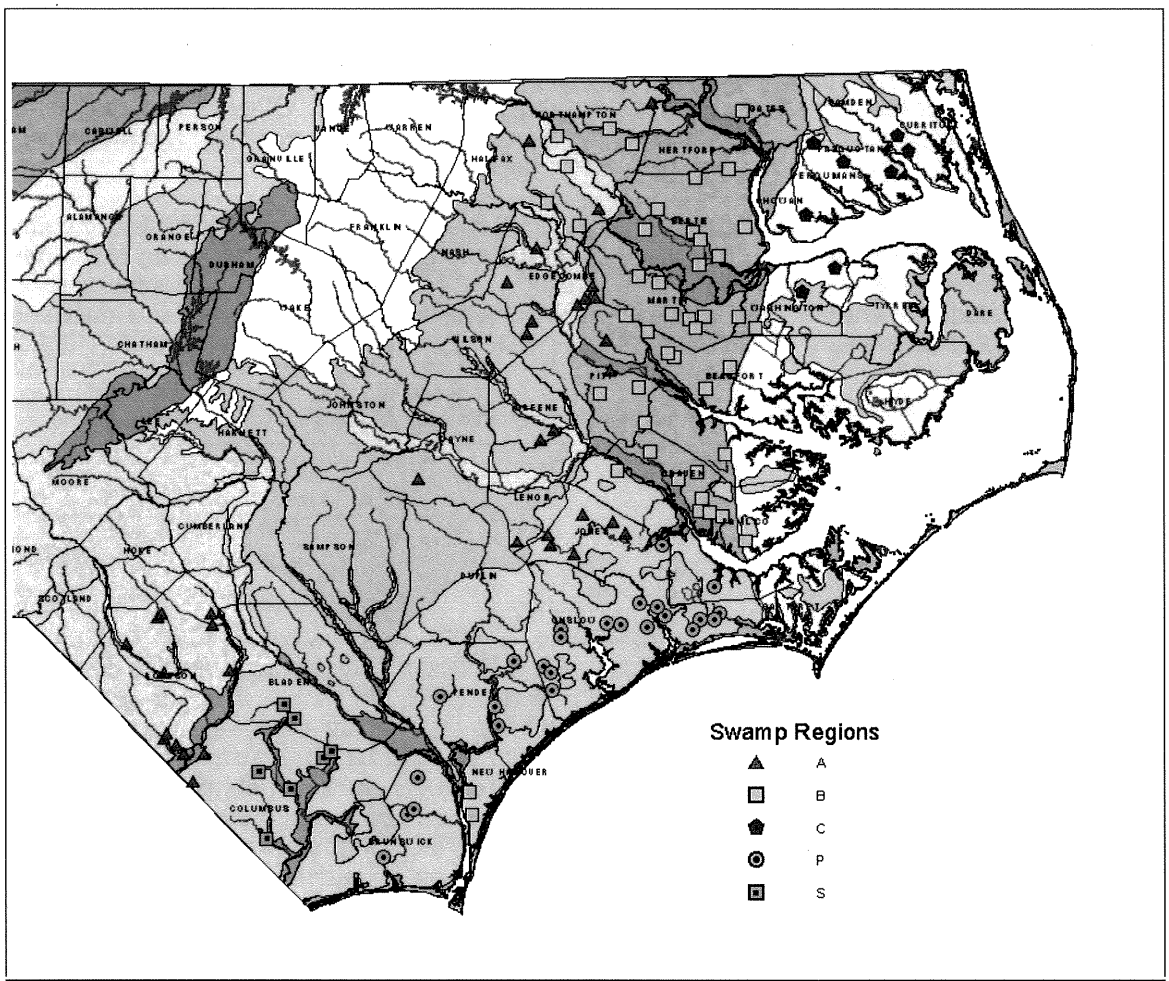


Figure 1. Swamp regions of North Carolina relative to Level IV Ecoregions (shaded areas)

3. Region B. This area generally coincides with the Mid-Atlantic Flatwoods ecoregion (63e), bounded on the south by the Neuse River and on the east by the Suffolk scarp. It also includes some of the Mid-Atlantic Floodplains and Low Terraces ecoregion (63n). A small section is also located along the southern coast. This region is generally defined by a lack of Heptageniid mayflies, especially *Stenonema*. *Stenonema modestum*, however, sometimes is found in coastal A streams within Region B.

4. Region P. This area is based on the Nonriverine Swamps and Peatlands ecoregion (63c). These streams flow through the Carolina Flatwoods (63h), but have their headwaters in the Nonriverine Swamps and Peatlands ecoregion (63c). Both the peatlands in the headwaters and the sandier soils of this region contribute to greater flow constancy relative to adjacent swamp regions. Most of the reference sites in this region have a distinct channel. Region P streams are characterized by a higher diversity of Polycentropidae (*Polycentropus*, *Lype diversa*, and *Nyctiophylax moestus*). Many of these streams also support the caddisfly *Hydropsyche decalda*.

5. Region S. Region S is also located in the Carolina Flatwoods (63h), but this is an area of very highly braided streams and extended low-flow periods. This area also has more clay soils and lower mean annual runoff (Giese and Mason, 1993). Region S has lower diversity than adjacent swamp regions.

6. Region A. Region A comprises the remainder of the swamp streams, located in the Atlantic Southern Loam Plains ecoregion (65l) and the Rolling Coastal Plain ecoregion (65m). This is a different Level III ecoregion, Southeastern Plains ecoregion(65), than the previous swamp regions which are in the Middle Atlantic Coastal Plain ecoregion (63). This area also contains many Coastal A streams.

Swamp stream criteria evaluate a stream based on three benthic macroinvertebrate metrics (Total taxa richness, EPT taxa richness, and Biotic Index) and the coastal plain form habitat value. The values for each of these metrics is used to derive a score for each metric, using the tables and graphs below. There are only three possible scores for each metric. A **score of 5** is assigned if the metric value falls within the

range **for Natural**, a **score of 3** is assigned to values in the range **for Moderate** and a **score of 1** is assigned to values in the range given **for Severe**. The final site score is derived by the formula:

Site Score = [(2xBI score + Habitat Score + EPT S score + Taxa Richness Score) – 5]/2

The biotic index is given greater weight than the other metrics (multiplied by 2), as this was shown to be the most reliable way to compare swamp streams. A value of 5 is subtracted from the sum of the scores (so that the lowest score is zero), and the sum is divided by 2 (as there were no odd numbers in the initial scores). This calculation produces a range of site scores from 0-10.

Most references sites (95%) were shown to have a **site score of 9-10** and this range was established as the Site Score criterion **for Natural** conditions. The remaining scores were separated into stress categories of **Moderate (4-8)** and **Severe (1-3)**. The Severe rating was set so that at least two of the four metrics must separately indicate severe stress (a score of 1), unless the biotic index metric scores a 1.

Deriving Swamp Stream Metric Scores

Corrected Total Taxa Richness (ST) equals actual total taxa richness; or add + 8 for streams with a braided channel. Swamp regions A, P, S, and B have different criteria for pH values below 5.5. Region C uses the same criteria for all pH values.

Corrected Total Taxa Richness Values

Region:	A, P, and S			B			C		
Category:	Natural	Moderate	Severe	Natural	Moderate	Severe	Natural	Moderate	Severe
Metric Score	5	3	1	5	3	1	5	3	1
pH Value							Any pH values		
≥5.5	>51	35-51	<35	>38	25-38	<25	>34	0-34	ND
5.4	>49	32-49	<32	>36	23-36	<23			
5.3	>46	29-46	<29	>34	21-34	<21			
5.2	>43	26-43	<26	>32	19-32	<19			
5.1	>40	23-40	<23	>30	17-30	<17			
5.0	>37	20-35	<20	>28	≤28	ND			
4.9	>35	17-35	<17	>26	≤26	ND			
4.8	>33	13-33	<13	>24	≤24	ND			
4.7	>30	10-30	<10	>22	≤22	ND			
4.6	>28	0-28	ND	>20	≤20	ND			
4.5	>26	0-26	ND	>18	≤18	ND			
4.4	>23	0-23	ND						
4.3	>20	0-20	ND						
4.2	>17	0-17	ND						
4.1	>14	0-14	ND=No Data (so Category is not used)						
≤4.0	**Do Not Rate** for any region-community affected mainly by pH -probably should not be sampled								

Biotic Index (BI)

Biotic Index values generally show no clear relationship between pH and channel type, and did not require any correction. Slightly elevated values are expected, however, for pH < 4.0, suggesting that these streams may be more difficult to evaluate.

Biotic Index Values

Region:		A/P/S	B	C
Category	Score			
Natural	5	<6.8	<7.0	<7.2
Moderate Stress	3	6.8-7.5	7.0-7.9	7.2-8.1
Severe Stress	1	>7.5	>7.9	>8.1

Corrected EPT taxa richness (EPT S)

First make a correction to EPT taxa richness of +2 for streams with a braided channel. Corrected EPT taxa richness is not clearly related to pH for Regions S and B, so criteria for these swamp regions are independent of pH. Region C has few EPT taxa that this metric does not apply, but if not scored as a 1an

odd rather than even number will result. A value of 2 is added to the final score of a region C site to produce a comparable score.

Corrected EPT Richness Values

Region:	A and P			S			B		
Category:	Natural	Moderate	Severe	Natural	Moderate	Severe	Natural	Moderate	Severe
Metric Score	5	3	1	5	3	1	5	3	1
pH Value				Any pH value			Any pH value		
≥5.5	>17	7-17	0-6	>10	6-10	0-5	>5	2-4	0-1
5.4	>15	6-15	0-5						
5.3	>13	5-13	0-4						
5.2	>11	4-11	0-3						
5.1	>9	3-9	0-2						
5.0	>8	0-8	ND						
4.9	>7	0-7	ND						
4.8	>6	0-6	ND						
4.7	>5	0-5	ND						
4.6	>4	0-4	ND						
4.5	>4	ND	ND						

ND=No Data (so Severe category is not used, and only a score of 3 or 5 is possible)

Habitat scores (Range is 0-100) do not require any modification for ecoregion or stream type. Based on reference site conditions, the following criteria were established:

Natural	Moderate	Severe
>79	60-79	<60

Midge Deformity Analysis

When a discharge contains both organics and toxic chemicals, the resulting community is often dominated by typical organic indicator species, especially *Chironomus* larvae. Under conditions of organic loading (low dissolved oxygen, high BOD), it would be useful to deduce the presence or absence of toxic chemicals. Researchers have shown that deformities in chironomid larvae (especially Chironomus) are associated with contaminated sediments. Using larvae from old samples and toxicity information from the DWQ Aquatic Toxicology Group, a good correlation was found between toxicity and *Chironomus* mentum deformities, leading to the use of analysis of these deformities as a screening tool for toxicity. At least 20-25 *Chironomus* heads should be slide mounted from any site to be screened.

Deformities are classified into three groups:

Class I: Slight deformities which are difficult to separate from "chipped" teeth.
Class II. Clear deformities, including extra teeth, missing teeth, large gaps, and distinct asymmetry.
Class III. Severe deformation which includes at least two Class II characters.

A "Toxic Score" is computed for each site which gives greater weight to more severe deformities:

$$\frac{[\#\text{ Class I} + 2(\#\text{ Class II}) + 3(\#\text{ Class III})] \times 100}{\text{Total \# larvae}}$$

No significant between-group differences were found for Excellent, Good and Good-Fair nontoxic sites. The percent deformities for these unpolluted sites averaged about 5%, with a mean toxic score of about 7. Fair and Poor nontoxic sites are combined into a polluted/nontoxic group, with a deformity rate of 12% and a mean toxic score of 18. "Nontoxic" conditions for this group includes solely organic dischargers (animal wastes) and natural organic loading (swamps). A Fair/Toxic group had a 25% deformity rate and a mean toxic score of 52. A further significant increase was seen for the Poor/Toxic group: mean deformity rate = 45%, mean toxic score = 100. Both toxic groups also are characterized by a high proportion of Class II and Class III deformities.

Quality Assurance

Quality assurance begins with following the procedures found in this manual, or documenting any changes in methods. It includes taking proper care of equipment, looking for holes in nets before sampling, and rinsing all nets and tubs carefully between sites. All meters must be calibrated before and after use, if called for in the meter's operating manual, and a record maintained of calibrations. Quality assurance of field sampling is also done by conducting "overlap" samples. Two separate collections by different teams

at the same site and within 2-3 weeks, with no appreciable rains in between, should be conducted annually to determine that reproducible results are being attained. In addition, field crews typically are not made up of the same three benthic biologists, so consistency in sampling is enhanced by this continuous change of staff on a field crew.

Taxonomic quality control in the laboratory is maintained in several ways. Organisms are first identified using current, regional identification manuals and other appropriate taxonomic literature. If questions occur, identifications are verified by other taxonomists in the Biological Assessment Unit. In order to maintain consistency in the taxonomic identifications, a Benthos Taxonomy Document has been compiled for the EPT and Coleoptera orders. This document specifies the level of identification to be used (genus or species), the references to be used for the IDs, and any pertinent ecological or distribution data available. This document will be updated regularly and other orders added as resources allow. Copies of all taxonomic papers used have been placed in a readily accessible location in the laboratory for the use of all benthic biologists. Taxonomic assistance is obtained from specialists when appropriate.

Reference specimens (most verified by taxonomic experts) are maintained in a reference cabinet, and samples are stored for future reference. A reference specimen list is maintained, and updated periodically. Also, random samples are re-identified for taxonomic consistency. Each benthic biologist is responsible to roll two dice after ten samples have been completed. The sample corresponding with the dice number is given to another biologist for verification. Each biologist has a number and the dice are rolled again to determine which biologist gets the sample to QA. Identification of the QA sample should begin as soon as it is received, and must be completed within one week, if in the office. After QA discussions (which may involve more than one biologist) the lead benthic biologist logs the information into a QA log book. If a QA accuracy of 90% or greater is not found, then the prior 10 samples will be re-identified by the lead biologist and the original identifier.

Benthic Macroinvertebrate Basinwide Monitoring

A Benthic Macroinvertebrate Ambient Network (BMAN) was begun in 1982 at seventy five stations across the state. It grew out of a federal program designed to address long term trends in water quality through a network of fixed monitoring stations. BMAN sampling was conducted every summer (late June to early September) from 1982 through 1990 using the standard qualitative method of sampling.

Beginning in 1991, the ambient summer sampling effort was directed toward specific river basins in given years based on the NPDES permitting schedule. Biological monitoring will generally be conducted three years prior to the year of permit renewal for the basin. This will allow biological data to be incorporated in basin assessment, and subsequently into the management plan for each basin. Benthos data will be included, by subbasin, into an Environmental Sciences Branch basinwide assessment report, that will include all data from the basin that is collected by the Branch, and a review of pertinent data and information from other sources. At this time all of the 17 river basins in the state have been sampled twice for the basinwide monitoring process and basin assessment reports have been prepared for all 17. The third round of basinwide sampling has begun and second reports are completed for most basins. Beginning in 2000, all basin assessment reports are being put on the Environmental Sciences Section web page, as they are completed. An appendix in older report lists all benthos sites sampled, with results, since 1983.

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Appendix 1. Tolerance Values for Benthic Macroinvertebrates Used in NCBI. Many other taxa have been collected less than 25 times and have not been assigned a TV, and are not used in the NCBI.

Order	Family	Latin Name	Taxa Entry	TV
CO	DRYOPIDAE	HELICHUS SP	HELICH	4.6
	DYTISCIDAE	AGABUS SPP	AGABUS	8.9
		CELINA SPP	CELINA	8
		COPELATUS SPP	COPELA	10
		COPTOTOMUS SPP	COPTOT	9.3
		DERONECTES GRISEOSTRIATUS	DERONE GRIS	4
		DERONECTES SP	DERONE	4
		HYDATICUS BIMARGINATUS	HYDATI BIMA	9.1
		HYDROPORUS MELLITUS	HYDROP MELL	4
		HYDROPORUS SPP	HYDROP	8.6
		LACCOPHILUS SPP	LACCOP	10
		LIOPOREUS PILATEI	LIOPOR PILA	3
		LIOPOREUS SPP	FALLOP	3
		NEOPORUS SPP	NEOPOR	8.6
		RHANTUS SPP	RHANTU	3.6
	ELMIDAE	ANCYRONYX VARIEGATUS	ANCYRO VARI	6.5
		DUBIRAPHIA SPP	DUBIRA	5.9
		DUBIRAPHIA VITTATA	DUBIRA VITT	4.1
		MACRONYCHUS GLABRATUS	MACRO GLAB	4.6
		MICROCYLLOEPUS PUSILLUS	MICROCY PUS	2.1
		OPTIOSERVUS OVALIS	OPTIOS OVAL	2.4
		OPTIOSERVUS SPP	OPTIOS	2.4
		OULIMNIUS LATIUSCULUS	OULIMN LATI	1.8
		OULIMNIUS SPP	OULIMN	1.8
		PROMORESIA ELEGANS	PROMOR ELEG	2.2
		PROMORESIA SPP	PROMOR	2.4
		PROMORESIA TARDELLA	PROMOR TARD	0
		STENELMIS ANTENNALIS	STENEL ANTE	3
		STENELMIS CONCINNA	STENEL CONC	1
		STENELMIS CONVEXULA	STENEL CONV	3
		STENELMIS CRENATA	STENEL CREN	7
		STENELMIS FUSCATA	STENEL FUSC	3
		STENELMIS GAMMONI	STENEL GAMM	1
		STENELMIS GROSSA	STENEL GROS	5
		STENELMIS HARLEYI	STENEL HARL	1
		STENELMIS LIGNICOLA	STENEL LIGN	3
		STENELMIS MERA	STENEL MERA	3
		STENELMIS MIRABILIS	STENEL MIRA	2
		STENELMIS MORSEI	STENEL MORS	1
		STENELMIS N SP	STENEL NSP	3
		STENELMIS SANDERSONI	STENEL SAND	3
		STENELMIS SINUATA	STENEL SINU	1
		STENELMIS SPP	STENEL	5.1
		STENELMIS WILLIAMI	STENEL WILL	1
		STENELMIS XYLONASTIS	STENEL XYLO	3
	GYRINIDAE	DINEUTUS SPP	DINEUT	5.5
		GYRINUS SPP	GYRINU	6.2
	HALIPLIDAE	HALIPLUS SPP	HALIPL	8.7
		PELTODYTES LENGI	PELTOD LENG	8
		PELTODYTES SPP	PELTOD	8.7
	HYDROPHILIDAE	BEROSUS SPP	BEROSU	8.4
		ENOCHRUS SPP	ENOCHR	8.8
		HELOPHORUS SPP	HELOPH	7.6
		HYDROBIOMORPHA CASTA	HYDROBIO CA	0
		HYDROCHUS SPP	HYDROCH	6.6
		LACCOBIUS SP	LACCOB	7.3
		SPERCHOPSIS TESSELLATUS	SPERCH TESS	6.1
		TROPISTERNUS SPP	TROPIS	9.7
	NOTERIDAE	HYDROCANTHUS SPP	HYDROCA	7.1
	PSEPHENIDAE	ECTOPRIA NERVOSA	ECTOPR NERV	4.2
		PSEPHENUS HERRICKI	PSEPHE HERR	2.4
	PTILODACTYLIDAE	ANCHYTARSUS BICOLOR	ANCHYT BICO	3.6
CR	ASELLIDAE	ASELLUS FORBESI	ASELLU FORB	6
		ASELLUS LATICAUDATUS	ASELLU LATI	6
		ASELLUS OBTUSUS	ASELLU OBTU	7
		ASELLUS RACOVITZAI AUSTRALIS	ASELLU RA/A	5.5
		ASELLUS SP1	ASELLU SP1	4
		ASELLUS SP2	ASELLU SP2	7
		ASELLUS SP3	ASELLU SP3	4
		ASELLUS SP4	ASELLU SP4	3
		CAECIDOTEA SP (STREAMS)	ASELLU	9.1
		LIRCEUS SPP	LIRCEU	7.9
	CAMBARIDAE	CAMBARIDAE	ASTACIDAE	7.5
		CAMBARUS (J.) TUCKASEGEE	CAMBAR TUCK	2

Order	Family	Latin Name	Taxa Entry	TV
CR	CAMBARIDAE	CAMBARUS (P.) ROBUSTUS	CAMBAR ROBU	4
		CAMBARUS BARTONI	C BARTON	4.6
		CAMBARUS SPP	CAMBARU	7.6
		ORCONECTES (P.) RUSTICUS	ORCONE RUST	6
		ORCONECTES CRISTAVARIUS	ORCONE SPB	5.5
		ORCONECTES SPP	ORCONE	2.6
		PROCAMBARUS (O.) A. ACUTUS	PROCAM ACUT	7
		PROCAMBARUS CLARKII	PROCAM CLAR	7
		PROCAMBARUS SPP	PROCAM	7
	GAMMARIDAE	CRANGONYX SERRATUS	CRANGO SERR	7.9
		CRANGONYX SPP	CRANGO	7.9
		GAMMARUS FASCIATUS	GAMMAR FASC	9.1
		GAMMARUS SPP	GAMMAR	9.1
	PALAEMONIDAE	PALAEMONETES PALUDOSUS	PALAEM PALU	7.1
		PALAEMONETES SPP	PALAEM	7.1
	TALITRIDAE	HYALLELA AZTECA	HYALEL AZTE	7.8
DI	CHIRONOMIDAE	ABLABESMYIA ANNULATA	ABLABE ANNU	2
		ABLABESMYIA MALLOCHI	ABLABE MALL	7.2
		ABLABESMYIA PARAJANTA/JANTA	ABLABE PA/J	7.4
		ABLABESMYIA PELEENSIS	ABLABE PELE	9.7
		ABLABESMYIA SIMPSONI	ABLABE SIMP	4
		ABLABESMYIA SPP	ABLABE	7.2
		APSECTROTANYPUS JOHNSONI	APSECT JOHN	0.1
		APSECTROTANYPUS SP	APSECT	1
		BRILLIA SPP	BRILLI	5.2
		BRUNDINIELLA EUMORPHA	BRUNDI EUMO	1.7
		CARDIOCLADIUS SPP	CARDIO	5.9
		CHIRONOMUS SPP	CHIRON	9.6
		CLADOPELMA SPP	CLADOP	3.5
		CLADOTANYTARSUS SP2	CLADOT SP2	2.1
		CLADOTANYTARSUS SP2A	CLADOT SP2A	2.1
		CLADOTANYTARSUS SP5	CLADOT SP5	7.4
		CLADOTANYTARSUS SP6	CLADOT SP6	1.7
		CLADOTANYTARSUS SP9 (Epler sp F)	CLADOT SP9	3.2
		CLADOTANYTARSUS SPB	CLADOT SPB	7
		CLADOTANYTARSUS SPD	CLADOT SPD	2
		CLADOTANYTARSUS SPP	CLADOT	4.1
		CLINOTANYPUS PINGUIS	CLINOT PING	8.7
		COELOTANYPUS CONCINNUS	COELOT CONC	8
		COELOTANYPUS SPP	COELOT	8
		CONCHAPELOPIA GROUP	CONCHA	8.4
		CORYNONEURA SPP	CORYNO	6
		CRICOTOPUS BICINCTUS: C/O SP1	C/O SP1	8.5
		CRICOTOPUS CYLINDRACEUS: C/O SP14	C/O SP14	2.3
		CRICOTOPUS INFUSCATUS GR: C/O SP5	C/O SP5	9
		CRICOTOPUS NR TRIFASCIA: C/O SP36	C/O SP36	2.8
		CRICOTOPUS OBNIXUS GR?	CRICOT OBNI	0.1
		CRICOTOPUS VARIPES GR: C/O SP6	C/O SP6	7.6
		CRICOTOPUS VIERIENSIS GR: C/O SP46	C/O SP46	4.4
		CRICOTOPUS/ORTHOCLADIUS SP2	C/O SP2	3.8
		CRICOTOPUS/ORTHOCLADIUS SP51	C/O SP51	3.4
		CRICOTOPUS/ORTHOCLADIUS SP52	C/O SP52	5.4
		CRICOTOPUS/ORTHOCLADIUS SP60	C/O SP60	1.4
		CRICOTOPUS/ORTHOCLADIUS SP7	C/O SP7	5.6
		CRICOTOPUS/ORTHOCLADIUS SP8	C/O SP8	4.6
		CRICOTOPUS/ORTHOCLADIUS SP9	C/O SP9	10
		CRYPTOCHIRONOMUS BLARINA GR	CRYPTO BLAR	7.4
		CRYPTOCHIRONOMUS FULVUS	CRYPTO FULV	6.4
		CRYPTOCHIRONOMUS SPP	CRYPTO	6.4
		CRYPTOTENDIPES SPP	CRYPTOT	6.2
		DEMICRYPTOCHIRONOMUS SP1	DEMICR SP1	2.1
		DEMICRYPTOCHIRONOMUS SP2	DEMICR SP2	2.1
		DEMICRYPTOCHIRONOMUS SPP	DEMICR	2.1
		DIAMESA SPP	DIAMES	8.1
		DICROTENDIPES LUCIFER	DICROT LUCI	8
		DICROTENDIPES MODESTUS	DICROT MODE	8.7
		DICROTENDIPES NEOMODESTUS	DICROT NEOM	8.1
		DICROTENDIPES NERVOSUS	DICROT NERV	9.8
		DICROTENDIPES SIMPSONI	DICROT SIMP	10
		DICROTENDIPES SPP	DICROT	8.1
		DIPLOCLADIUS CULTRIGER	DIPLOC CULT	7.4
		EINFELDIA SPP	EINFEL	7.1
		ENDOCHIRONOMUS NIGRICANS	ENDOCH NIGR	7.8
		EPOICOCLADIUS SP 2 (EPLER)	EPOICO SP2	0.1
		EPOICOCLADIUS SPP	EPOICO	0.1
		EUKIEFFERIELLA BREHMI GR (E SP12)	E SP12	2.7
		EUKIEFFERIELLA BREVICALCAR GR (E SP6)	E SP6	2.2

Order	Family	Latin Name	Taxa Entry	TV
DI	CHIRONOMIDAE	EUKIEFFERIELLA CLARIPENNIS GR (E SP11)	E SP11	5.6
		EUKIEFFERIELLA DEVONICA GR (E SP2)	E SP2	2.6
		EUKIEFFERIELLA GRACEI GR (ESP14)	E SP14	3.4
		EUKIEFFERIELLA PSEUDOMONTANA GR	E PSEUDO	4
		GENUS NR NANOCLADIUS B	G NR NAN B	6.5
		GLYPTOTENDIPES SPP	GLYPTO	9.5
		GOELDICHIRONOMUS HOLOPRASINUS	GOELDI HOLO	10
		HARNISCHIA SPP	HARNIS	9.1
		HELENIELLA SPP	HELENI	0
		HETEROTRISSOCLADIUS SP2	HETEROT SP2	0
		HETEROTRISSOCLADIUS SPP	HETEROT	5.2
		HYDROBAENUS SPP	HYDROBA	9.5
		HYPORHYGMA QUADRIPUNCATUM	HYPORH QUAD	6
		KIEFFERULUS DUX	KIEFFE DUX	10
		KIEFFERULUS SPP	KIEFFE	8
		KRENOSMITTIA SPP	KRENOS	0
		LABRUNDINIA NEOPILOSELLA	LABRUN NEOP	6
		LABRUNDINIA PILOSELLA	LABRUN PILO	5.9
		LABRUNDINIA SPP	LABRUN	5.9
		LABRUNDINIA VIRESCENS	LABRUN VIRE	4.3
		LARSIA SPP	LARSIA	9.3
		LIMNOPHYES SPP	LIMNOP	7.4
		LOPESCLADIUS SPP	LOPESC	1.7
		MICROPSECTRA SP1	MICROP SP1	0.7
		MICROPSECTRA SPP	MICROP	1.5
		MICROTENDIPES SP1	MICROT SP1	5.5
		MICROTENDIPES SP2	MICROT SP2	1.5
		MICROTENDIPES SP3	MICROT SP3	5.5
		MICROTENDIPES SPP	MICROT	5.5
		NANOCLADIUS DOWNESI	N DOWNE	2.5
		NANOCLADIUS SPP	NANOCL	7.1
		NATARSIA SPP	NATARS	10
		NILOTANYPUS SPP	NILOTA	3.9
		NILOTHAUMA SPP	NILOTH	5
		O. (EUORTHOCLADIUS) TYPE III: C/O SP13	C/O SP13	6
		ODONTOMESA FULVA	ODONTO FULV	5.9
		OLIVERIDIA SPP	OLIVER	3.2
		OMISUS PICA	OMISUS PICA	4
		ORTHOCLADIUS ROBACKI: C/O SP12	C/O SP12	6.6
		ORTHOCLADIUS (EUORTHOCLADIUS): C/O SP20	C/O SP20	5.3
		ORTHOCLADIUS (EUORTHOCLADIUS): C/O SP3	C/O SP3	9.1
		ORTHOCLADIUS CLARKEI GR: C/O SP54	C/O SP54	5.7
		ORTHOCLADIUS NR NIGRITUS: C/O SP47	C/O SP47	0.4
		ORTHOCLADIUS OBUMBRATUS GR: C/0 SP10	C/O SP10	8.5
		PAGASTIA SPP	PAGASTI	1.8
		PAGASTIELLA OSTANSA	PAGAST OSTA	2.5
		PARACHAETOCLADIUS SPP	PARACHA	0
		PARACHIRONOMUS ABORTIVUS	PARACH ABOR	8.3
		PARACHIRONOMUS MONOCHROMUS	PARACH MONO	9.6
		PARACHIRONOMUS PECTINATELLAE	PARACH PECT	6.5
		PARACHIRONOMUS SPP	PARACH	9.4
		PARACLADOPELMA NEREIS	PARACL NERE	0.9
		PARACLADOPELMA SPECIES 1 JACKSON	PARACL SP1	2.5
		PARACLADOPELMA SPP	PARACL	5.5
		PARACLADOPELMA UNDINE	PARACL UNDI	4.9
		PARAKIEFFERIELLA SP4	PARAKI SP4	5.4
		PARAKIEFFERIELLA SPP	PARAKI	5.4
		PARAKIEFFERIELLA TRIQUETA	PARAKI TRIQ	5.2
		PARALAUTERBORNIELLA NIGROHALTERALIS	PARALA NIGR	4.8
		PARAMERINA SPP	PARAME	4.3
		PARAMETRIOCNEMUS LUNDBECKI	PARAMET LUN	3.7
		PARAPHAENOCLADIUS SP2	PARAPH SP2	3.3
		PARATANYTARSUS SPP	PARATA	8.5
		PARATENDIPES CONNECTENS (GROUP)	PARATE CONN	4
		PARATENDIPES SPP	PARATE	5.1
		PARATRICHOCLADIUS SPP	PARATRI	8.5
		PENTANEURA SPP	PENTAN	4.7
		PHAENOPSECTRA FLAVIPES	PHAENO FLAV	7.9
		PHAENOPSECTRA SP2	PHAENO SP2	6.5
		PHAENOPSECTRA SP3	PHAENO SP3	6.6
		PHAENOPSECTRA SP4	PHAENO SP4	4.5
		PHAENOPSECTRA SPP	PHAENO	6.5
		POLYPEDILUM ANGULUM	P ANGULU	5.2
		POLYPEDILUM AVICEPS	P AVICEP	3.7
		POLYPEDILUM CONVICTUM	P CONVIC	4.9
		POLYPEDILUM FALLAX	P FALLAX	6.4
		POLYPEDILUM HALTERALE	P HALTER	7.3

Order	Family	Latin Name	Taxa Entry	TV
DI	CHIRONOMIDAE	POLYPEDILUM ILLINOENSE	P ILLINO	9
		POLYPEDILUM LAETUM	P LAETUM	1.4
		POLYPEDILUM SCALAENUM	P SCALAE	8.4
		POTTHASTIA GAEDI	POTTHA GAED	2
		POTTHASTIA LONGIMANUS	POTTHA LONG	6.5
		POTTHASTIA SPP	POTTHA	6.4
		PROCLADIUS SPP	PROCLA	9.1
		PRODIAMESA OLIVACEA	PRODIA OLIV	9.5
		PSECTROCLADIUS SPP	PSECTRO	3.6
		PSECTROTANYPUS DYARI	PSECTR DYAR	10
		PSECTROTANYPUS SPP	PSECTR	10
		PSEUDOCHIRONOMUS SPP	PSEUDOC	5.4
		PSEUDORTHOCLADIUS SPP	PSEUDOR	1.5
		RHEOCRICOTOPUS ROBACKI	RHEOCR SP1	7.3
		RHEOCRICOTOPUS SP3	RHEOCR SP3	0.9
		RHEOCRICOTOPUS SPP	RHEOCR	7.3
		RHEOCRICOTOPUS TUBERCULATUS	RHEOCR SP2	5.1
		RHEOSMITTIA SP1 NR DELICATULA	RHEOSM SP1	7
		RHEOSMITTIA SPP	RHEOSM	7
		RHEOTANYTARSUS SPP	RHEOTA	5.9
		ROBACKIA CLAVIGER	ROBACK CLAV	2.2
		ROBACKIA DEMEIJEREI	ROBACK DEME	3.7
		SAETHERIA TYLUS	SAETHE TYLU	7.1
		STELECHOMYIA PERPULCHRA	STELEC PERP	5
		STEMPELLINA SPP	STEMPE	0
		STEMPELLINELLA SPP	STEMPEL	4.6
		STENOCHIRONOMUS SPP	STENOC	6.5
		STICTOCHIRONOMUS SPP	STICTO	6.5
		STILOCLADIUS CLINOPECTEN	STILOC CLIN	1
		SUBLETTEA COFFMANI	SUBLET COFF	1.6
		SYMPOSIOCLADIUS LIGNICOLA	SYMPOS LIGN	5.3
		SYMPOTTHASTIA SPP	SYMPOT	5.1
		SYNORTHOCLADIUS SPP	SYNORT	4.4
		TANYPUS SPP	TANYPU	9.2
		TANYTARSUS SP10	TANYTA SP10	4.6
		TANYTARSUS SP13	TANYTA SP13	4.9
		TANYTARSUS SP2	TANYTA SP2	6.8
		TANYTARSUS SP2C	TANYTA SP2C	4.7
		TANYTARSUS SP3	TANYTA SP3	6.8
		TANYTARSUS SP4	TANYTA SP4	2.7
		TANYTARSUS SP5	TANYTA SP5	2.2
		TANYTARSUS SP6	TANYTA SP6	7.5
		TANYTARSUS SPP	TANYTA	6.8
		THIENEMANIELLA SPP	THIENE	5.9
		THIENEMANIELLA XENA	THIENE XENA	5.9
		TRIBELOS JUCUNDUS	PHAENO JUCU	6.3
		TRIBELOS SPP	TRIBEL	6.3
		TVETENIA BAVARICA GR (E SP1)	E SP1	3.7
		TVETENIA DISCOLORIPES GR (E SP3)	E SP3	3.6
		UNNIELLA MULTIVIRGA	G NR OLIV	0
		XENOCHIRONOMUS XENOLABIS	XENOCH XENO	7.1
		XYLOTOPUS PAR	XYLOTO PAR	6
		ZALUTSCHIA SPP	ZALUTS	3
		ZAVRELIA SPP	ZAVREL	5.3
		ZAVRELIMYIA SPP	ZAVRELI	9.1
DIM	BLEPHARICERIDAE	BLEPHARICERA SPP	BLEPHA	2
	CERATOPOGONIDAE	ALLUAUDOMYIA SPP	ALLUAU	6
		ATRICHOPOGON SPP	ATRICH	6.5
		CULICOIDES SPP	CULICO	7.7
		PALPOMYIA (COMPLEX)	PALPOM	6.9
	CULICIDAE	ANOPHELES SPP	ANOPHE	8.6
		CHAOBORUS PUNCTIPENNIS	CHAOBO PUNC	8.5
		CHAOBORUS SPP	CHAOBO	8.5
		CULEX SPP	CULEX	10
	DIXIDAE	DIXA SPP	DIXA	2.6
	EMPIDIDAE	EMPIDIDAE	EMPIDIDAE	7.6
	MUSCIDAE	LIMNOPHORA SPP	LIMNOPH	8.4
	PSYCHODIDAE	PSYCHODA SPP	PSYCHOD	9.6
	RHAGIONIDAE	ATHERIX LANTHA	ATHERI LANT	2.1
		ATHERIX SPP	ATHERI	2.1
	SIMULIIDAE	PROSIMULIUM MIXTUM	PROSIM MIXT	4
		PROSIMULIUM SPP	PROSIM	6
		SIMULIUM (PHOSTERODOROS)	SIMULI NSP	4
		SIMULIUM (PHOSTERODOROS) SPP	SIMULI (PH)	4
		SIMULIUM CONGAREENARUM	SIMULI CONG	4.9
		SIMULIUM SPP	SIMULI	6
		SIMULIUM TUBEROSUM	SIMULI TUBE	4.4

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DIM	SIMILIIDAE	SIMULIUM VENUSTUM	SIMULI VENU	7.1
		SIMULIUM VITTATUM	SIMULI VITT	8.7
	STRATIOMYIDAE	STRATIOMYS SP	STRATI	8.1
	SYRPHIDAE	ERISTALIS SP	ERISTA	9.7
	TABANIDAE	CHRYSOPS SPP	CHRYSO	6.7
		TABANUS SPP	TABANU	9.2
	TANYDERIDAE	PROTOPLASA FITCHII	PROTOP FITC	4.3
	TIPULIDAE	ANTOCHA SPP	ANTOCH	4.3
		DICRANOTA SPP	DICRAN	0
		ERIOPTERA	ERIOPT	4.6
		HEXATOMA SPP	HEXATO	4.3
		LIMONIA SPP	LIMONI	9.6
		POLYMEDA/ORMOSIA SPP	POL/OR	6.3
		PSEUDOLIMNOPHILA SPP	PSEUDOL	7.2
		TIPULA SPP	TIPULA	7.3
EP	BAETIDAE	ACENTRELLA AMPLA	ACENTR AMPL	3.6
		ACENTRELLA FEMORELLA	ACENTR FEMO	5.5
		ACENTRELLA SP	ACENTR	4
		ACENTRELLA TURBIDA	ACENTR TURB	4
		ACERPENNA PYGMAEA	ACERPE PYGM	3.9
		BAETIS ALACHUA	BAETIS ALAC	4
		BAETIS ANOKA	BAETIS ANOK	4
		BAETIS ARMILLATUS	BAETIS ARMI	5
		BAETIS BIMACULATUS	BAETIS BIMA	6
		BAETIS CINCTUTUS	BAETIS CINC	2
		BAETIS DUBIUS	BAETIS DUBI	5.8
		BAETIS EPHIPPIATUS	BAETIS EPHI	3.7
		BAETIS FLAVISTRIGA	BAETIS FLAV	7
		BAETIS FRONDALIS	BAETIS FRON	7.5
		BAETIS INTERCALARIS	BAETIS INTE	7
		BAETIS PLUTO	BAETIS PLUT	4.3
		BAETIS PROPINQUUS	BAETIS PROP	5.8
		BAETIS PUNCTIVENTRIS	BAETIS PUNC	4
		BAETIS TRICAUDATUS	BAETIS TRIC	1.6
		BAETOPUS TRISHAE	BAETOP TRIS	0.1
		CALLIBAETIS SP	CALLIB	9.8
		CENTROPTILUM MINOR	CENTRO MINOR	2
		CENTROPTILUM SP 2	CENTRO SP2	6
		CENTROPTILUM SPP	CENTRO	6.6
		CENTROPTILUM TRIANGULIFER	CENTRO TRIA	6
		CLOEON SPP	CLOEON	6.6
		DIPHETOR HAGENI	BAETIS HAGE	1.6
		HETEROCLOEON SP	HETERO	3.5
		HETEROCLOEON CURIOSUM	HETERO CURI	3.5
		PLAUDITUS DUBIUS GR	PLAUDI DUBI	5.8
		PROCLOEON SPP	PROCLOEON	5
		PROCLOEON APPALACHIA	PROCLO APPA	6
		PROCLOEON RIVULARE	PROCLO RIVU	6
		PROCLOEON RUBROPICTUM	PROCLO RUBR	6
		PROCLOEON RUFOSTRIGATUM	PROCLO RUFO	6
		PROCLOEON SP1	PROCLO SP1	6
		PROCLOEON VIRIDOCULARE	PROCLO VIRI	6
		PSEUDOCENTROPTILOIDES USA	PSEUDOC USA	6
		PSEUDOCLOEON SPP	PSEUDO	4
	BAETISCIDAE	BAETISCA BERNERI	BAETISC BER	2
		BAETISCA CAROLINA	BAETISC CAR	3.5
		BAETISCA GIBBERA	BAETISC GIB	1.4
		BAETISCA SPP	BAETISC	3.4
	CAENIDAE	AMERCAENIS SP	AMERCAE	1
		BRACHYCERCUS SPP	BRACHY	3
		CAENIS SPP	CAENIS	7.4
		CERCOBRACHYS SP	CERCOB	1
	EPHEMERELLIDAE	ATTENELLA ATTENUATA	ATTENE ATTE	1.6
		DANNELLA LITA	DANNEL LITA	0
		DANNELLA SIMPLEX	DANNEL SIMP	3.6
		DRUNELLA ALLEGHENIENSIS	DRUNEL ALLE	0.8
		DRUNELLA CONESTEE	DRUNEL CONE	0
		DRUNELLA CORNUTELLA	DRUNEL CORN	0
		DRUNELLA LATA	DRUNEL LATA	0
		DRUNELLA SP	DRUNEL	0.1
		DRUNELLA TUBERCULATA	DRUNEL TUBE	0
		DRUNELLA WALKERI	DRUNEL WALK	1
		DRUNELLA WAYAH	DRUNEL WAYA	0
		EPHEMERELLA AURIVILLII	E AURIVI	1
		EPHEMERELLA CATAWBA	E CATAWB	4.4
		EPHEMERELLA DOROTHEA	E DOROTH	6
		EPHEMERELLA FLORIPARA	E FLORIP	2

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EP	EPHEMERELLIDAE	EPHEMERELLA HISPIDA	E HISPID	0.8
		EPHEMERELLA INVARIA (GR)	E INVARI	2.4
		EPHEMERELLA NEEDHAMI	E NEEDHA	0
		EPHEMERELLA ROSSI (GR)	E ROSSI	0
		EPHEMERELLA ROTUNDA	E ROTUND	2.6
		EPHEMERELLA SEPTENTRIONALIS	E SEPTEN	2
		EPHEMERELLA SPP	EPHEME	2
		EPHEMERELLA SUBVARIA	E SUBVAR	0
		EURYLOPHELLA BICOLOR	EURYLO BICO	4.9
		EURYLOPHELLA COXALIS	EURYLO COXA	3.4
		EURYLOPHELLA DORIS	EURYLO DORI	4.3
		EURYLOPHELLA ENOENSIS	EURYLO ENOE	4
			EURYLO LUTU	4
		EURYLOPHELLA FUNERALIS	EURYLO FUNE	2.1
		EURYLOPHELLA MINIMELLA	EURYLO MINI	2
		EURYLOPHELLA PRUDENTALIS	EURYLO PRUD	4
		EURYLOPHELLA SPP	EURYLO	4.3
		EURYLOPHELLA TEMPORALIS	EURYLO TEMP	4.3
		EURYLOPHELLA VERISIMILIS	EURYLO VERI	4.3
		SERRATELLA CAROLINA	SERRAT CARO	0
		SERRATELLA DEFICIENS	SERRAT DEFI	2.8
		SERRATELLA SERRATA	SERRAT SER	1.9
		SERRATELLA SERRATOIDES	SERRAT SERR	1.7
		SERRATELLA SPICULOSA	SERRAT SPIC	0.1
	EPHEMERIDAE	EPHEMERA BLANDA	EPHEMER BLA	2
		EPHEMERA GUTTALATA	EPHEMER GUT	0
		EPHEMERA SPP	EPHEMER	2
		HEXAGENIA SPP	HEXAGE	4.9
		LITOBRANCHA RECURVATA	LITOBR RECU	0
	HEPTAGENIIDAE	CINYGMULA SUBAEQUALIS	CINYGM SUBA	0.1
		EPEORUS DISPAR	EPEORU DISP	1
		EPEORUS PLEURALIS	EPEORU PLEU	1.8
		EPEORUS RUBIDUS	EPEORU RUBI	1.2
		EPEORUS SPP	EPEORU	1.3
		HEPTAGENIA JULIA	HEPTAG JULI	0.1
		HEPTAGENIA MARGINALIS	HEPTAG MARG	2.3
		HEPTAGENIA PULLA	HEPTAG PULL	1.9
		HEPTAGENIA SPP	HEPTAG	2.6
		LEUCROCUTA APHRODITE	LEUCRO APHR	2.4
		LEUCROCUTA SPP	LEUCRO	2.4
		MACDUNNOA BRUNNEA	MACDUN BRUN	0.6
		NIXE FLOWERSI	NIXE FLOW	1
		NIXE NR INCONSPICUA	NIXE INCO	1
		NIXE SPP	NIXE	0.1
		RHITHROGENA AMICA	RHITHR AMIC	0.3
		RHITHROGENA EXILIS	RHITHR EXIL	0.3
		RHITHROGENA FUSCIFRONS	RHITHR FUSC	0.3
		RHITHROGENA SPP	RHITHR	0.3
		RHITHROGENA UHARI	RHITHR UHAR	0.3
		STENACRON CAROLINA	STENAC CARO	1.1
		STENACRON INTERPUNCTATUM	STENAC INTE	6.9
		STENACRON PALLIDUM	STENAC PALL	2.7
		STENONEMA CARLSONI	S CARLSO	2.1
		STENONEMA EXIGUUM	S EXIGUU	3.8
		STENONEMA FEMORATUM	S FEMORA	7.2
		STENONEMA INTEGRUM	S INTEGR	5.8
		STENONEMA ITHACA	S ITHACA	3.6
		STENONEMA LENATI	S LENATI	2.3
		STENONEMA MEDIOPUNCTATUM	S MEDIOP	3.8
		STENONEMA MERIRIVULANUM	S MERIRI	0.1
		STENONEMA MODESTUM	S MODEST	5.5
		STENONEMA N SP (WILSON CR)	S WILSON	1
		STENONEMA PUDICUM	S PUDICU	2
		STENONEMA SMITHAE	S SMITHA	5.5
		STENONEMA TERMINATUM	S TERMIN	4.1
		STENONEMA VICARIUM	S VICARI	1.3
	LEPTOPHLEBIIDAE	HABROPHLEBIA VIBRANS	HABROPH VIB	0
		HABROPHLEBIODES SPP.	HABROPH	1
		LEPTOPHLEBIA BRADLEYI	LEPTOP BRAD	3
		LEPTOPHLEBIA CUPIDA	LEPTOP CUPI	6
		LEPTOPHLEBIA INTERMEDIA	LEPTOP INTE	6
		LEPTOPHLEBIA SPP	LEPTOP	6.2
		PARALEPTOPHLEBIA SPP	PARALE	0.9
	METRETOPODIDAE	SIPHLOPLECTON SPP	SIPHLOP	3.3
	NEOEPHEMERIDAE	NEOEPHEMERA COMPRESSA	NEOEPH COMP	0
		NEOEPHEMERA PURPUREA	NEOEPH PURP	1.6
		NEOEPHEMERA YOUNGI	NEOEPH YOUN	0.9

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EP	OLIGONEURIIDAE	ISONYCHIA SPP	ISONYC	3.5
	POLYMITARCYIDAE	EPHORON LEUKON	EPHORO LEUK	1.3
	POTAMANTHIDAE	POTAMANTHUS SPP	POTAMA	1.5
	SIPHLONURIDAE	AMELETUS LINEATUS	AMELET LINE	2.4
		SIPHLONURUS SPP	SIPHLO	5.8
	TRICORYTHIDAE	LEPTOHYPHES SPP	LEPTOH	1.4
		TRICORYTHODES SPP	TRICOR	5.1
GA	ANCYLIDAE	FERRISSIA SPP	FERRIS	6.6
		LAEVAPEX FUSCUS	LAEVAP FUSC	7.5
	HYDROBIIDAE	AMNICOLA SPP	AMNICO	5.2
		SOMATOGYRUS SPP	SOMATOG	6.4
	LYMNAEIDAE	PSEUDOSUCCINEA COLUMELLA	PSEUD COL	7.7
		STAGNICOLA SPP	STAGNI	8.2
	PHYSIDAE	PHYSELLA SPP	PHYSEL	8.8
	PLANORBIDAE	GYRAULUS DEFLECTUS	GYRAUL DEFL	5
		GYRAULUS PARVUS	GYRAUL PARV	6
		GYRAULUS SPP	GYRAUL	4.2
		HELISOMA ANCEPS	HELISO ANCE	6.2
		HELISOMA TRIVOLVIS	HELISO TRIV	5.9
		MENETUS DILATATUS	MENETU DILA	8.2
		PLANORBELLA SPP	PLANOR	6.8
		PROMENETUS EXACUOUS	PROMEN EXAC	5
	PLEUROCERIDAE	ELIMIA SP	ELIMIA	2.5
		LEPTOXIS SPP	LEPTOX	1.8
	VALVATIDAE	VALVATA BICARINATA	VALVAT BICA	8
	VIVIPARIDAE	CAMPELOMA DECISUM	CAMPEL DECI	6.5
HE	BELOSTOMATIDAE	BELOSTOMA SPP	BELOST	9.8
	CORIXIDAE	CORIXIDAE	CORIXIDAE	9
		SIGARA SPP	SIGARA	9.1
	NAUCORIDAE	PELOCORIS SPP	PELOCO	7
	NEPIDAE	RANATRA SPP	RANATR	7.8
	NOTONECTIDAE	NOTONECTA SPP	NOTONE	8.7
ME	CORYDALIDAE	CHAULIODES PECTINICORNIS	CHAULI PECT	9.6
		CHAULIODES RASTRICORNIS	CHAULI RAST	8.4
		CORYDALUS CORNUTUS	CORYDA CORN	5.2
		NIGRONIA FASCIATUS	NIGRON FASC	5.6
		NIGRONIA SERRICORNIS	NIGRON SERR	5
	SIALIDAE	SIALIS SPP	SIALIS	7.2
OD	AESHNIDAE	BASIAESCHNA JANATA	BASIAE JANA	7.4
		BOYERIA GRAFIANA	BOYERI GRAF	6.1
		BOYERIA VINOSA	BOYERI VINO	5.9
		GOMPHAESCHNA SP	GOMPHA	6
		NASIAESCHNA PENTACANTHA	NASIAE PENT	8.1
	CALOPTERYGIDAE	CALOPTERYX SPP	CALOPT	7.8
		HETAERINA SPP	HETAER	5.6
	COENAGRIONIDAE	ARGIA SEDULA	ARGIA SEDU	8.5
		ARGIA SPP	ARGIA	8.2
		ENALLAGMA SIGNATUM	ENALLA SIGN	8.9
		ENALLAGMA SPP	ENALLA	8.9
		ISCHNURA SPP	ISCHNU	9.5
		NEHALENNIA IRENE	NEHALE IREN	5
	CORDULEGASTERIDAE	CORDULEGASTER MACULATA	CORDUL MACU	5.7
		CORDULEGASTER SPP	CORDUL	5.7
	CORDULIIDAE	EPICORDULIA PRINCEPS	EPICOR PRIN	5.6
		EPICORDULIA SPP	EPICOR	5.6
		HELOCORDULIA SPP	HELOCO	4.8
		HELOCORDULIA UHLERI	HELOCO UHLE	4.9
		NEUROCORDULIA MOLESTA	NEUROC MOLE	1.8
		NEUROCORDULIA OBSOLETA	NEUROC OBSO	5.2
		NEUROCORDULIA SPP	NEUROC	5
		NEUROCORDULIA VIRGINIENSIS	NEUROC VIRG	2.1
		SOMATOCHLORA SPP	SOMATO	9.2
		TETRAGONEURIA CYNOSURA	TETRAG CYNO	8.5
		TETRAGONEURIA SPP	TETRAG	8.6
	GOMPHIDAE	DROMOGOMPHUS SPP	DROMOG	5.9
		GOMPHUS SPINICEPS	GOMPHU SPIN	5.1
		GOMPHUS SPP	GOMPHU	5.8
		HAGENIUS BREVISTYLUS	HAGENI BREV	4
		LANTHUS PARVULUS	LANTHU PARV	1.8
		LANTHUS SPP	LANTHU	1.8
		LANTHUS VERNALIS	LANTHU VERN	1.8
		OPHIOGOMPHUS SPP	OPHIOG	5.5
		PROGOMPHUS OBSCURUS	PROGOM OBSC	8.2
		STYLOGOMPHUS ALBISTYLUS	STYLOG ALBI	4.7
	LESTIDAE	ARCHILESTES GRANDIS	ARCHIL GRAN	8
		LESTES SPP	LESTES	9.4
	LIBELLULIDAE	ERYTHEMIS SIMPLICICOLLIS	ERYTHE SIMP	9.7

Order	Family	Latin Name	Taxa Entry	TV
OD	LIBELLULIDAE	LIBELLULA SPP	LIBELL	9.6
		PACHYDIPLAX LONGIPENNIS	PACHYD LONG	9.9
		PERITHEMIS SPP	PERITH	9.9
		PLATHEMIS LYDIA	PLATHE LYDI	10
		SYMPETRUM SPP	SYMPET	7.3
	MACROMIIDAE	DIDYMOPS TRANSVERSA	DIDYMO TRAN	2.4
		MACROMIA GEORGIANA	MACROM GEOR	6.2
		MACROMIA SPP	MACROM	6.2
OL	CAMBARINICOLIDAE	CAMBARINICOLIDAE	CAMBAR	6
		PTERODRILUS ALCICORNIS	PTEROD ALCI	5
	ENCHYTRAEIDAE	ENCHYTRAEIDAE	ENCHYTRAEI	9.8
	HAPLOTAXIDAE	HAPLOTAXIS GORDIOIDES	HAPLOT GORD	3.6
	LUMBRICULIDAE	LUMBRICULIDAE	LUMBRICULI	7
	MEGADRILE	MEGADRILE OLIGOCHAETE	MEGADRILE	9
		OPISTHOPORA	OPISTH	9
	NAIDIDAE	DERO SPP	DERO	10
		NAIS BEHNINGI	NAIS BEHN	8.9
		NAIS COMMUNIS	NAIS COMM	8.8
		NAIS SPP	NAIS	8.9
		NAIS VARIABILIS	NAIS VARI	8.9
		PRISTINA SPP	PRISTI	9.6
		PRISTINELLA	PRISTIN	7.7
		RIPISTES PARASITA	RIPIST PARA	2
		SLAVINA APPENDICULATA	SLAVIN APPE	7.1
		STYLARIA LACUSTRIS	STYLAR LACU	9.4
	TUBIFICIDAE	AULODRILUS LIMNOBIUS	AULODR LIMN	5.5
		AULODRILUS PAUCICHAETA	AULODR PAUC	6
		AULODRILUS PIGUETI	AULODR PIGU	5.5
		AULODRILUS PLURISETA	AULODR PLUR	2.9
		BRANCHIURA SOWERBYI	BRANCH SOWE	8.3
		ILYODRILUS TEMPLETONI	ILYODR TEMP	9.3
		ISOCHAETIDES CURVISETOSUS	ISOCHA CURV	6.8
		ISOCHAETIDES FREYI	ISOCHA FREY	8.6
		LIMNODRILUS CERVIX	LIMNOD CERV	9.9
		LIMNODRILUS HOFFMEISTERI	LIMNOD HOFF	9.5
		LIMNODRILUS SPP	LIMNOD	9.5
		LIMNODRILUS UDEKEMIANUS	LIMNOD UDEK	9.5
		QUISTADRILUS MULTISETOSUS	QUISTA MULT	3.9
		SPIROSPERMA NIKOLSKYI	SPIROS NIKO	5.3
		SPIROSPERMA SPP	PELOSC	5.4
		TUBIFEX TUBIFEX	TUBIFE TUBI	10
		TUBIFICIDAE	TUBIFI	7.1
OT	ERPOBDELLIDAE	ERPOBDELLA/MOOREOBDELLA	ERP/MO	8.3
		MOOREOBDELLA TETRAGON	MOOREO TETR	9.4
	GLOSSIPHONIIDAE	BATRACOBDELLA PHALERA	BATRAC PHAL	7.6
		HELOBDELLA ELONGATA	HELOBD ELON	9.5
		HELOBDELLA STAGNALIS	HELOBD STAG	8.6
		HELOBDELLA TRISERIALIS	HELOBD TRIS	9.2
		PLACOBDELLA PAPILLIFERA	PLACOB PAPI	9
		PLACOBDELLA PARASITICA	PLACOB PARA	8.7
		PLACOBDELLA SPP	PLACOB	9
	HIRUDINIDAE	MACROBDELLA DITETRA	MACROB DITE	4
		PHILOBDELLA GRACILIS	PHILOB GRAC	5
	HYDRACARINA	HYDRACARINA	HYDRAC	5.5
	NEMERTEA	NEMATODA	NEMATODA	6
	PLANARIIDAE	CURA FOREMANII	CURA FORE	5
		DUGESIA TIGRINA	DUGESI TIGR	7.2
	POLYCLAD	PROSTOMA GRAECENS	PROSTO GRAE	6.1
	PYRALIDAE	PETROPHILA SP	PETROP	2.1
		PYRALIDAE	PYRALI	2
	SISYRIDAE	CLIMACIA AREOLARIS	CLIMAC AREO	8.4
		CLIMACIA SPP	CLIMAC	8.4
PE	CORBICULIDAE	CORBICULA FLUMINEA	CORBIC FLUM	6.1
	SPHAERIIDAE	EUPERA CUBENSIS	EUPERA CUBE	5.7
		MUSCULIUM SP	MUSCUL	7.5
		PISIDIUM SPP	PISIDI	6.5
		SPHAERIUM SPP	SPHAER	7.6
	UNIONIDAE	ALASMIDONTA UNDULATA	ALASMI UNDU	1.2
		ALASMIDONTA VARICOSA	ALASMI VARI	0.1
		ELLIPTIO COMPLANATA	ELLIPT COMP	5.1
		ELLIPTIO LANCEOLATA	ELLIPT LANC	2.4
		ELLIPTIO SPP	ELLIPT	5.1
PL	CAPNIIDAE	ALLOCAPNIA SPP	ALLOCA	2.5
		PARACAPNIA ANGULATA	PARACA ANGU	0.1
	CHLOROPERLIDAE	ALLOPERLA SPP	ALLOPE	1.2
		HAPLOPERLA BREVIS	HAPLOP BREV	1
		SUWALLIA SPP	SUWALL	1.2

Order	Family	Latin Name	Taxa Entry	TV
PL	CHLOROPERLIDAE	SWELTSA SPP	SWELTS	0
	LEUCTRIDAE	LEUCTRA SPP	LEUCTR	2.5
	NEMOURIDAE	AMPHINEMURA SPP	AMPHIN	3.3
		PROSTOIA SP	PROSTO	5.8
		SHIPSA ROTUNDA	SHIPSA ROTU	0.3
		SOYEDINA SPP	SOYEDI	0
	PELTOPERLIDAE	TALLAPERLA SPP	TALLAP	1.2
	PERLIDAE	ACRONEURIA ABNORMIS	A ABNORM	2.1
		ACRONEURIA ARENOSA	A ARENOS	2.3
		ACRONEURIA CAROLINENSIS	A CAROLI	0
		ACRONEURIA LYCORIAS	A LYCORI	2.1
		ACRONEURIA MELA	A MELA	0.9
		ACRONEURIA PERPLEXA	A PERPLEX	1
		AGNETINA ANNULIPES	AGNETI ANNU	0
		AGNETINA CAPITATA	AGNETI CAPI	0
		AGNETINA FLAVESCENS	AGNETI FLAV	0
		AGNETINA SP	AGNETI	0
		BELONEURIA SP	BELONE	0
		ECCOPTURA XANTHENES	ECCOPT XANT	3.7
		NEOPERLA SPP	NEOPER	1.5
		PARAGNETINA FUMOSA	PARAGN FUMO	3.4
		PARAGNETINA ICHUSA	PARAGN ICHU	0
		PARAGNETINA IMMARGINATA	PARAGN IMMA	1.4
		PARAGNETINA KANSENSIS	PARAGN KANS	2
		PARAGNETINA MEDIA?	PARAGN MEDI	1
		PARAGNETINA SPP	PARAGN	1.5
		PERLESTA PLACIDA	PERLES PLAC	4.7
		PERLESTA SPP	PERLES	4.7
		PERLINELLA DRYMO	PERLIN DRYM	0
		PERLINELLA EPHYRE	PERLIN EPHY	1.3
	PERLODIDAE	CLIOPERLA CLIO	CLIOPE CLIO	4.7
		CULTUS DECISUS	CULTUS DECI	1.6
		DIPLOPERLA DUPLICATA	DIPLOP DUPL	2.7
		DIPLOPERLA MORGANI	DIPLOP MORG	1.4
		HELOPICUS BOGALOOSA	HELOPI BOGA	0
		HELOPICUS SPP	HELOPIC	0.8
		HELOPICUS SUBVARIANS	HELOPI SUBV	0.8
		ISOGENOIDES HANSONI	ISOGEN HANS	0.5
		ISOPERLA BILINEATA	I BILINE	5.4
		ISOPERLA DICALA	I DICALA	2.1
		ISOPERLA HOLOCHLORA	I HOLOCH	2
		ISOPERLA LATA	I LATA	0
		ISOPERLA NAMATA (GR)	I NAMATA	2
		ISOPERLA NR HOLOCHLORA	I NR HOLO	0
		ISOPERLA NR SLOSSONAE	I NR SLOS	1.2
		ISOPERLA ORATA	I ORATA	0
		ISOPERLA SIMILIS	I SIMILI	0.2
		ISOPERLA SLOSSONAE	I SLOSSO	1.8
		ISOPERLA SPECIES 10	I SP10	0
		ISOPERLA TRANSMARINA (GR)	I TRANSM	5.2
		MALIREKUS HASTATUS	MALIRE HAST	1.2
		REMENUS BILOBATUS	REMENU BILO	0.3
		YUGUS ARINUS	YUGUS ARIN	0
		YUGUS BULBOSUS	YUGUS BULB	0
		YUGUS SP	YUGUS	0
	PTERONARCYIDAE	PTERONARCYIDAE	PTERONARCI	1.6
		PTERONARCYS DORSATA	PTERON DORS	1.8
		PTERONARCYS SPP	PTERON	1.7
	TAENIOPTERYGIDAE	STROPHOPTERYX SPP	STROPH	2.7
		TAENIOPTERYX BURKSI	TAENIO BURK	6.1
		TAENIOPTERYX METEQUI	TAENIO METE	1.4
		TAENIOPTERYX SPP	TAENIO	5.4
TR	APATANIIDAE	APATANIA SP	APATAN	0.6
	BRACHYCENTRIDAE	BRACHYCENTRUS APPALACHIA	BRACHYC APP	0.6
		BRACHYCENTRUS CHELATUS	BRACHYC CHE	0.6
		BRACHYCENTRUS LATERALIS	BRACHYC LAT	0.6
		BRACHYCENTRUS NIGROSOMA	BRACHYC NIG	2.3
		BRACHYCENTRUS NUMEROSUS	BRACHYC NUM	1.7
		BRACHYCENTRUS SPINAE	BRACHYC SPI	0.01
		BRACHYCENTRUS SPP	BRACHYC	2.1
		MICRASEMA BENNETTI	MICRAS BENN	0.1
		MICRASEMA BURKSI	MICRAS BURK	0.1
		MICRASEMA CHARONIS	MICRAS CHAR	0.8
		MICRASEMA RICKERI	MICRAS RICK	0.1
		MICRASEMA RUSTICUM	MICRAS RUST	0.1
		MICRASEMA WATAGA	MICRAS WATA	2.6
	CALAMOCERATIDAE	ANISOCENTROPUS PYRALOIDES	ANISOC PYRA	0.9

Order	Family	Latin Name	Taxa Entry	TV
TR	CALAMOCERATIDAE	HETEROPLECTRON AMERICANUM	HETEROP AME	3.2
	DIPSEUDOPSIDAE	PHYLOCENTROPUS SPP	PHYLOC	6.2
	GLOSSOSOMATIDAE	AGAPETUS SPP	AGAPET	0
		GLOSSOSOMA SPP	GLOSSO	1.6
		MATRIOPTILA JEANAE	MATRIO JEAN	0
		PROTOPTILA SPP	PROTOPT	2.6
	GOERIDAE	GOERA SPP	GOERA	0.1
	HELICOPSYCHIDAE	HELICOPSYCHE BOREALIS	HELICO BORE	0
		HELICOPSYCHE PARALIMNELLA	HELICO PARA	0
	HYDROPSYCHIDAE	ARCTOPSYCHE IRRORATA	ARCTOP IRRO	0
		CHEUMATOPSYCHE SPP	CHEUMA	6.2
		DIPLECTRONA MODESTA	DIPLEC MODE	2.2
		HYDROPSYCHE BETTENI	H BETTEN	7.8
		HYDROPSYCHE DECALDA	H DECALD	4.3
		HYDROPSYCHE DEMORA	H DEMORA	2.1
		HYDROPSYCHE ELISSOMA	H ELISSO	4
		HYDROPSYCHE INCOMMODA	H INCOMM	4.8
		HYDROPSYCHE PHALERATA	H PHALER	3.6
		HYDROPSYCHE ROSSI	H ROSSI	4.8
		HYDROPSYCHE SCALARIS	H SCALAR	2.1
		HYDROPSYCHE VENULARIS	H VENULA	5
		MACROSTEMUM SPP	MACROS	3.5
		PARAPSYCHE CARDIS	PARAPS CARD	0
		SYMPHITOPSYCHE ALHEDRA	SYMPHI ALHE	0
		SYMPHITOPSYCHE BIFIDA	SYMPHI BIFI	2.2
		SYMPHITOPSYCHE BRONTA	SYMPHI BRON	5.3
		SYMPHITOPSYCHE MACLEODI	SYMPHI MACL	0.6
		SYMPHITOPSYCHE MOROSA	SYMPHI MORO	2.6
		SYMPHITOPSYCHE SLOSSONAE	SYMPHI SLOS	0.1
		SYMPHITOPSYCHE SPARNA	SYMPHI SPAR	2.7
		SYMPHITOPSYCHE VENTURA	SYMPHI VENT	0.1
		SYMPHITOPSYCHE WALKERI	SYMPHI WALK	1
	HYDROPTILIDAE	HYDROPTILA SPP	HYDROPT	6.2
		LEUCOTRICHIA PICTIPES	LEUCOT PICT	4.1
		OCHROTRICHIA SPP	OCHROT	4
		ORTHOTRICHIA SPP	ORTHOT	8.3
		OXYETHIRA SPP	OXYETH	2.2
		STACTOBIELLA SPP	STACTO	1.3
	LEPIDOSTOMATIDAE	LEPIDOSTOMA SPP	LEPIDO	0.9
	LEPTOCERIDAE	CERACLEA ANCYLUS	CERACL ANCY	2.3
		CERACLEA CAMA?	CERACL CAMA	2.5
		CERACLEA ENODIS	CERACL ENOD	6.5
		CERACLEA FLAVA	CERACL FLAV	0
		CERACLEA JOANNAE	CERACL JOAN	0
		CERACLEA MACULATA	CERACL MACU	6.5
		CERACLEA MENTIEA	CERACL MENT	0
		CERACLEA N SP NR TARSIPUNCTATA	CERACL NR TA	2
		CERACLEA NEPHA?	CERACL NEPH	2
		CERACLEA NR EXCISA	CERACL EXCI	2
		CERACLEA OPHIODERUS	CERACL OPHI	2.4
		CERACLEA RESURGENS	CERACL RESU	2.9
		CERACLEA SPP	CERACL	2
		CERACLEA TRANSVERSA	CERACL TRAN	2.5
		MYSTACIDES SEPULCHRALUS	MYSTAC SEPU	2.7
		NECTOPSYCHE CANDIDA	NECTOP CAND	5.5
		NECTOPSYCHE EXQUISITA	NECTOP EXQU	4.1
		NECTOPSYCHE PAVIDA	NECTOP PAVI	4.1
		NECTOPSYCHE SPP	NECTOP	2.9
		OECETIS GEORGIA	OECETI GEOR	3
		OECETIS INCONSPICUA	OECETI INCO	1.9
		OECETIS MORSEI	OECETI MORS	0
		OECETIS NOCTURNA	OECETI NOCT	4.1
		OECETIS PERSIMILLIS	OECETI PERS	4.7
		OECETIS SP A (FLOYD)	OECETI SPA	2
		OECETIS SP D (FLOYD)	OECETI SPD	0.1
		OECETIS SP F (FLOYD)	OECETI SPF	3.5
		OECETIS SP1	OECETI SP1	4.7
		OECETIS SP2	OECETI SP2	4.3
		OECETIS SPP	OECETI	4.7
		SETODES ARENATUS	SETODE AREN	0.5
		SETODES SPP	SETODE	0
		SETODES STEHRI	SETODE STEH	0.5
		TRIAENODES IGNITUS	TRIAEN IGNI	4.6
		TRIAENODES INJUSTA	TRIAEN INJU	2.5
		TRIAENODES MELACA	TRIAEN MELA	4.1
		TRIAENODES OCHRACEUS	TRIAEN OCHR	4.5
		TRIAENODES PERNA	TRIAEN PERN	4.1

Order	Family	Latin Name	Taxa Entry	TV
TR	LEPTOCERIDAE	TRIAENODES SPP	TRIAEN	4.5
	LIMNEPHILIDAE	HYDATOPHYLAX ARGUS	HYDATO ARGU	2.2
		IRONOQUIA PUNCTATISSIMA	IRONOQ PUNC	7.8
		PYCNOPSYCHE DIVERGENS	PYCNOP DIVE	2.5
		PYCNOPSYCHE GENTILIS	PYCNOP GENT	0.6
		PYCNOPSYCHE GUTTIFER	PYCNOP GUTT	2.6
		PYCNOPSYCHE LEPIDA	PYCNOP LEPI	2.7
		PYCNOPSYCHE LUCULENTA	PYCNOP LUCU	2.5
		PYCNOPSYCHE SCABRIPENNIS	PYCNOP SCAB	2.5
		PYCNOPSYCHE SPP	PYCNOP	2.5
	MOLANNIDAE	MOLANNA BLENDA	MOLANN BLEN	6.1
		MOLANNA TRYPHENA	MOLANN TRYP	2.5
	ODONTOCERIDAE	PSILOTRETA FRONTALIS	PSILOT FRON	0
		PSILOTRETA LABIDA	PSILOT LABI	0
		PSILOTRETA SPP	PSILOT	0
	PHILOPOTAMIDAE	CHIMARRA SPP	CHIMAR	2.8
		DOLOPHILODES SPP	DOLOPH	0.8
		WORMALDIA SPP	WORMAL	0.7
	PHRYGANEIDAE	OLIGOSTOMIS PARDALIS	OLIGOS PARD	1.4
		PTILOSTOMIS SPP	PTILOS	6.4
	POLYCENTROPODIDAE	CYRNELLUS FRATERNUS	CYRNEL FRAT	7.3
		NEURECLIPSIS SPP	NEUREC	4.2
		NYCTIOPHYLAX CELTA	NYCTIO CELT	0.7
		NYCTIOPHYLAX MOESTUS	NYCTIO MOES	3.3
		NYCTIOPHYLAX NEPHOPHILUS	NYCTIO NEPH	0.8
		NYCTIOPHYLAX SPP	NYCTIO	0.9
		POLYCENTROPUS SPP	POLYCE	3.5
	PSYCHOMYIIDAE	LYPE DIVERSA	LYPE DIVE	4.1
		PSYCHOMYIA FLAVIDA	PSYCHO FLAV	2.9
		PSYCHOMYIA NOMADA	PSYCHO NOMA	2
	RHYACOPHILIDAE	RHYACOPHILA ACUTILOBA	R ACUTIL	0
		RHYACOPHILA ATRATA	R ATRATA	0
		RHYACOPHILA CAROLINA	R CAROLI	0
		RHYACOPHILA FUSCULA	R FUSCUL	1.9
		RHYACOPHILA LEDRA	R LEDRA	3.9
		RHYACOPHILA MELITA	R MELITA	0
		RHYACOPHILA MINOR	R MINOR	0
		RHYACOPHILA NIGRITA	R NIGRIT	0
		RHYACOPHILA TORVA	R TORVA	1.6
		RHYACOPHILA VUPHIPES	R VUPHIP	0
	SERICOSTOMATIDAE	AGARODES SPP	AGAROD	0.7
		FATTIGIA PELE	FATTIG PELE	0.9
	UENOIDAE	NEOPHYLAX CONCINNUS	NEOPHY CONC	1.5
		NEOPHYLAX CONSIMILIS	NEOPHY CONS	1.5
		NEOPHYLAX FUSCUS	NEOPHY FUSC	0.1
		NEOPHYLAX MITCHELLI	NEOPHY MITC	0.1
		NEOPHYLAX OLIGIUS	NEOPHY OLIG	2.2
		NEOPHYLAX ORNATUS	NEOPHY ORNA	1.5
		NEOPHYLAX SPP	NEOPHY	2.2

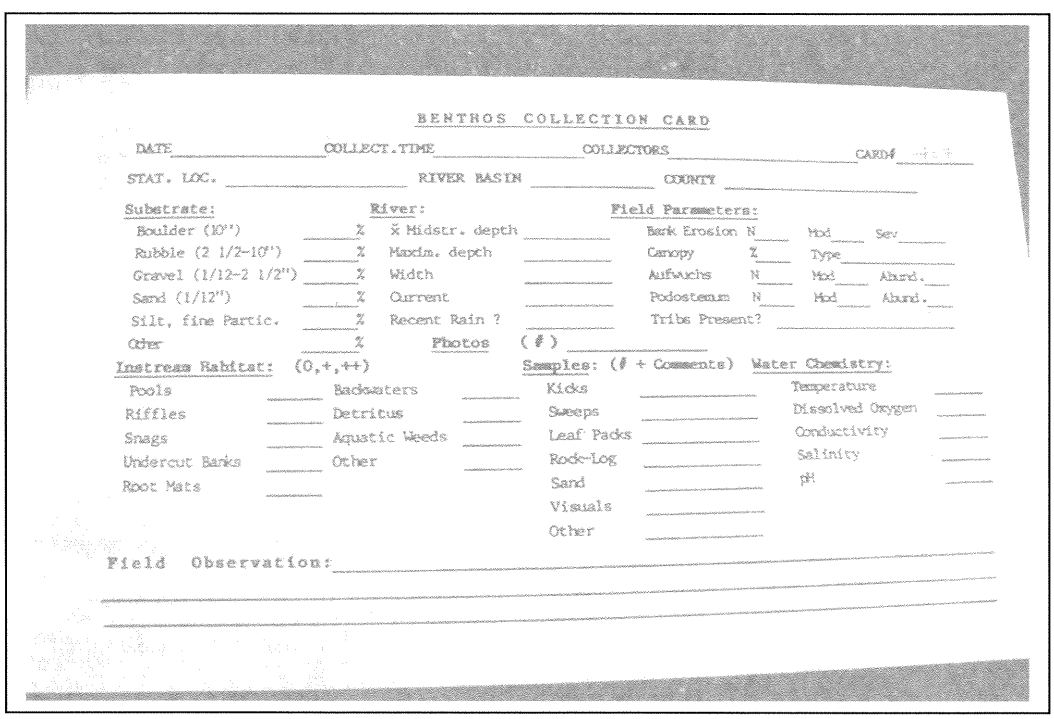
Appendix 2. Benthic Macroinvertebrate Field and Lab Equipment

A. Field Equipment

Kick nets
Sweep nets
Sand bag sampler
Fine-mesh samplers
Petite Ponar
Wash tubs
Sieve buckets
Plastic picking trays
Camera and film, or Digital camera
Forceps
Meters (YSI, pH, etc)
Waders, rain gear
Vials, and containers for vials
Alcohol
Labels and collection cards, pencils
Habitat Assessment Forms
GPS Unit
First Aid Kit
Insect Repellant

B. Laboratory Equipment and Supplies

Dissecting microscopes
Compound microscopes
Alcohol
Formalin
Polyvinyl lactophenol (CMC Mounting Media)
Rose bengal solution
Vials
Forceps
Cover slips
Microscope slides
Petri dishes
Squeeze bottles
Dissecting needles
Slide labels
Slide holders
Benthic Macroinvertebrate lab sheets



BENTHOS COLLECTION CARD

DATE _____ COLLECT.TIME _____ COLLECTORS _____ CARD# _____

STAT. LOC. _____ RIVER BASIN _____ COUNTY _____

Substrate:
Boulder (10") ____%
Rubble (2 1/2-10") ____%
Gravel (1/12-2 1/2") ____%
Sand (1/12") ____%
Silt, fine Partic. ____%
Other ____%

River:
x̄ Midstr. depth _____
Maxim. depth _____
Width _____
Current _____
Recent Rain ? _____
Photos (#) _____

Field Parameters:
Bank Erosion N____ Mod____ Sev____
Canopy %____ Type _____
Aufwuchs N____ Mod____ Abund.____
Podosteum N____ Mod____ Abund.____
Tribs Present? _____

Instream Habitat: (0,+,++)
Pools ____ Backwaters ____
Riffles ____ Detritus ____
Snags ____ Aquatic Weeds ____
Undercut Banks ____ Other ____
Root Mats ____

Samples: (# + Comments)
Kicks _____
Sweeps _____
Leaf Packs _____
Rock-Log _____
Sand _____
Visuals _____
Other _____

Water Chemistry:
Temperature ____
Dissolved Oxygen ____
Conductivity ____
Salinity ____
pH ____

Field Observation: _____

BENTHIC MACROINVERTEBRATE LAB SHEET

Water Body_____ Road/County_____

Type Sample_____ Collection Card No._____

Date Collected_____ Collectors/Analyst_____

Ephemeroptera	A,C,R		Plecoptera	A,C,R		Odonata	A,C,R	
			Misc Diptera			Oligochaeta		
			Chiros			Megaloptera		
						Crustacea		
Trichoptera								
						Mollusca		
			Coleoptera			Other		

Total Taxa_____ Bioclassification_____

Total EPT_____ EPT N _____

Biotic Index_____ EPT BI _____

Notes_____

Habitat Assessment Field Data Sheet
Coastal Plain Streams

TOTAL SCORE_____

Biological Assessment Unit, DWQ

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream_____Location/road: _____(Road Name_____)County_____

Date_____**CC#**_____Basin_____Subbasin_____

Observer(s)_____ Type of Study: ☐ Fish ☐Benthos ☐ Basinwide ☐Special Study (Describe) _____

Latitude _____Longitude _____Ecoregion: ☐ CA ☐ SWP ☐ Sandhills ☐ CB

Water Quality: Temperature_____^{0}C DO _____mg/l Conductivity (corr.) _____µS/cm pH _____

Physical Characterization: Visible land use refers to immediate area that you can see from sampling location. Check off what you observe driving thru the watershed in watershed land use.

Visible Land Use: _____%Forest _____%Residential _____%Active Pasture _____% Active Crops
_____%Fallow Fields _____% Commercial _____%Industrial _____%Other - Describe:_____

Watershed land use ☐ Forest ☐ Agriculture ☐Urban ☐ Animal operations upstream

Width: (meters) Stream_____ Channel (at top of bank)_____ **Stream Depth**: (m) Avg_____Max ____
☐ **Width variable** ☐**Braided channel** ☐**Large river >25m wide**
Bank Height (from deepest part of channel to top of bank): (m)_____

Flow conditions : ☐High ☐Normal ☐Low

Channel Flow Status

Useful especially under abnormal or low flow conditions.

A. Water reaches base of both banks, minimal channel substrate exposed ..... ☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed..... ☐
C. Water fills 25-75% of available channel, many logs/snags exposed..... ☐
D. Root mats out of water..... ☐
E. Very little water in channel, mostly present as standing pools..... ☐

Turbidity: ☐Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes) ☐Green tinge
Good potential for Wetlands Restoration Project?? ☐ YES ☐ NO
Details_____

☐Channelized ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐Recent overbank deposits ☐Bar development ☐Sewage smell
☐Excessive periphyton growth ☐Heavy filamentous algae growth

Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
Weather Conditions:_____**Photos:** ☐N ☐Y ☐Digital ☐35mm

Remarks:_____
TYPICAL STREAM CROSS SECTION DIAGRAM ON BACK

I. Channel Modification

	Score
A. Natural channel-minimal dredging.....	15
B. Some channelization near bridge, or historic (>20 year old), and/or bends beginning to reappear..	10
C. Extensive channelization, straight as far as can see, channelized ditch.....	5
D. Banks shored with hard structure, >80% of reach disrupted, instream habitat gone.....	0

Remarks_____ Subtotal____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >50% of the reach is snags, and 1 type is present, circle the score of 16. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as **R**are, **C**ommon, or **A**bundant.

____**Sticks** ____**Snags/logs** ____**Undercut banks or root mats** ____**Macrophytes** ____**Leafpacks**

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>50% Score	30-50% Score	10-30% Score	<10% Score
4 or 5 types present.....	20	15	10	5
3 types present.....	18	13	8	4
2 types present.....	17	12	7	3
1 type present.....	16	11	6	2
No substrate for benthos colonization and no fish cover.....0				

☐ No woody vegetation in riparian zone Remarks_____ Subtotal_____

III. Bottom Substrate (silt, clay, sand, detritus, gravel) look at entire reach for substrate scoring.

	Score
A. Substrate types mixed	
1. gravel dominant.....	15
2. sand dominant.....	13
3. detritus dominant.....	7
4. silt/clay/muck dominant.....	4
B. Substrate homogeneous	
1. nearly all gravel.....	12
2. nearly all sand	7
3. nearly all detritus.....	4
4. nearly all silt/clay/muck.....	1

Remarks_____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow.

	Score
A. Pools present	
1. Pools Frequent (>30% of 100m length surveyed)	
a. variety of pool sizes.....	10
b. pools about the same size (indicates pools filling in).....	8
2. Pools Infrequent (<30% of the 100m length surveyed)	
a. variety of pool sizes.....	6
b. pools about the same size.....	4
B. Pools absent	
1. Deep water/run habitat present.....	4
2. Deep water/run habitat absent.....	0
	Subtotal_____

Remarks_____ Page Total_____

V. Bank Stability and Vegetation

	Score	Score
A. Banks stable or no banks, just flood plain		
1. little or no evidence of erosion or bank failure, little potential for erosion	10	10
B. Erosion areas present		
1. diverse trees, shrubs, grass; plants healthy with good root systems.....	9	9
2. few trees or small trees and shrubs; vegetation appears generally healthy.....	7	7
3. sparse vegetation; plant types and conditions suggest poorer soil binding.....	4	4
4. mostly grasses, few if any trees and shrubs, high erosion and failure potential at high flow	2	2
5. little or no bank vegetation, mass erosion and bank failure evident.....0	0	

Total_____

Remarks_____

VI. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** canopy with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent.....	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal.....	7
D. Stream with **minimal** canopy - full sun in all but a few areas.....	2
E. **No canopy** and no shading.....	0

Subtotal____

Remarks_____

VII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters.....	5	5
2. zone width 12-18 meters.....	4	4
3. zone width 6-12 meters.....	3	3
4. zone width < 6 meters.....	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters.....	4	4
b. zone width 12-18 meters.....	3	3
c. zone width 6-12 meters.....	2	2
d. zone width < 6 meters.....	1	1
2. breaks common		
a. zone width > 18 meters.....	3	3
b. zone width 12-18 meters.....	2	2
c. zone width 6-12 meters.....	1	1
d. zone width < 6 meters.....	0	0

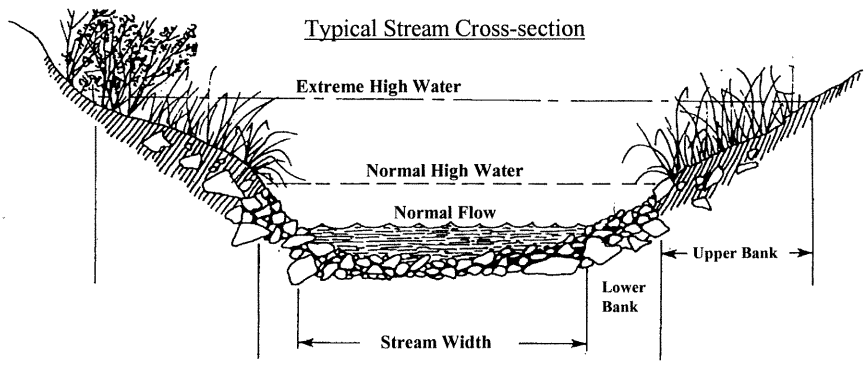
Total_____

Remarks_____

Page Total_____

TOTAL SCORE _____

Typical Stream Cross-section



This side is 45° bank angle.

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Biological Assessment Unit, DWQ **TOTAL SCORE_____**

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream_____Location/road: _____(Road Name_____)County_____

Date_____**CC#**_____Basin_____Subbasin_____

Observer(s)_____ Type of Study: ☐ Fish ☐Benthos ☐ Basinwide ☐Special Study (Describe) _____

Latitude _____Longitude _____Ecoregion: ☐ MT ☐ P ☐ Slate Belt ☐ Triassic Basin

Water Quality: Temperature_____^{0}C DO _____mg/l Conductivity (corr.) _____µS/cm pH _____

Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.

Visible Land Use: _____%Forest _____%Residential _____%Active Pasture _____% Active Crops
_____%Fallow Fields _____% Commercial _____%Industrial _____%Other - Describe:_____

Watershed land use : ☐Forest ☐Agriculture ☐Urban ☐ Animal operations upstream

Width: (meters) Stream_____ Channel (at top of bank)_____ **Stream Depth**: (m) Avg_____Max ____
☐ Width variable ☐ Large river >25m wide
Bank Height (from deepest part of riffle to top of bank-first flat surface you stand on): (m)_____

Bank Angle: _____° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)
☐ Channelized Ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐ Recent overbank deposits ☐Bar development ☐Buried structures ☐Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐Green tinge ☐ Sewage smell
Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
Flow conditions : ☐High ☐Normal ☐Low
Turbidity: ☐Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes)
Good potential for Wetlands Restoration Project?? ☐ YES ☐NO Details_____
Channel Flow Status
Useful especially under abnormal or low flow conditions.

A. Water reaches base of both lower banks, minimal channel substrate exposed	☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed.....	☐
C. Water fills 25-75% of available channel, many logs/snags exposed.....	☐
D. Root mats out of water.....	☐
E. Very little water in channel, mostly present as standing pools.....	☐

Weather Conditions:_____**Photos:** ☐N ☐Y ☐ Digital ☐35mm

Remarks:_____
_____

I. Channel Modification

	Score
A. channel natural, frequent bends	5
B. channel natural, infrequent bends (channelization could be old)	4
C. some channelization present	3
D. more extensive channelization, >40% of stream disrupted	2
E. no bends, completely channelized or rip rapped or gabioned, etc	0

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☐Banks of uniform shape/height

Remarks_____ Subtotal____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as **R**are, **C**ommon, or **A**bundant.

____Rocks ____Macrophytes ____Sticks and leafpacks ____Snags and logs ____Undercut banks or root mats

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>70% Score	40-70% Score	20-40% Score	<20% Score
4 or 5 types present	20	16	12	8
3 types present	19	15	11	7
2 types present	18	14	10	6
1 type present	17	13	9	5
No types present	0			

☐ No woody vegetation in riparian zone Remarks_____ Subtotal_____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

	Score
A. substrate with good mix of gravel, cobble and boulders	
1. embeddedness <20% (very little sand, usually only behind large boulders)	15
2. embeddedness 20-40%	12
3. embeddedness 40-80%	8
4. embeddedness >80%	3
B. substrate gravel and cobble	
1. embeddedness <20%	14
2. embeddedness 20-40%	11
3. embeddedness 40-80%	6
4. embeddedness >80%	2
C. substrate mostly gravel	
1. embeddedness <50%	8
2. embeddedness >50%	4
D. substrate homogeneous	
1. substrate nearly all bedrock	3
2. substrate nearly all sand	3
3. substrate nearly all detritus	2
4. substrate nearly all silt/ clay	1

Remarks_____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

	Score
A. Pools present	
1. Pools Frequent (>30% of 200m area surveyed)	
a. variety of pool sizes	10
b. pools about the same size (indicates pools filling in)	8
2. Pools Infrequent (<30% of the 200m area surveyed)	
a. variety of pool sizes	6
b. pools about the same size	4
B. Pools absent	0

Subtotal_____

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks_____

Page Total_____

V. Riffle Habitats

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

	Riffles **Frequent** Score	Riffles **Infrequent** Score
A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream....	16	12
B. riffle as wide as stream but riffle length is not 2X stream width	14	7
C. riffle not as wide as stream and riffle length is not 2X stream width	10	3
D. riffles absent.....	0	

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream Subtotal_____

VI. Bank Stability and Vegetation

FACE UPSTREAM	Left Bank Score	Rt. Bank Score
A. Banks stable		
1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion..	7	7
B. Erosion areas present		
1. diverse **trees**, shrubs, grass; plants healthy with good root systems.....	6	6
2. few trees or small trees and **shrubs**; vegetation appears generally healthy.....	5	5
3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding.....	3	3
4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow..	2	2
5. little or no bank vegetation, mass erosion and bank failure evident.....	0	0
		Total_____

Remarks_____

VII. Light Penetration Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

	Score
A. Stream with **good** canopy with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent.....	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal.....	7
D. Stream with **minimal** canopy - full sun in all but a few areas.....	2
E. **No canopy** and no shading.....	0

Remarks_____Subtotal____

VIII. Riparian Vegetative Zone Width

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

FACE UPSTREAM Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc)	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. width > 18 meters.....	5	5
2. width 12-18 meters.....	4	4
3. width 6-12 meters.....	3	3
4. width < 6 meters.....	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. width > 18 meters.....	4	4
b. width 12-18 meters.....	3	3
c. width 6-12 meters.....	2	2
d. width < 6 meters.....	1	1
2. breaks common		
a. width > 18 meters.....	3	3
b. width 12-18 meters.....	2	2
c. width 6-12 meters.....	1	1
d. width < 6 meters.....	0	0
		Total_____

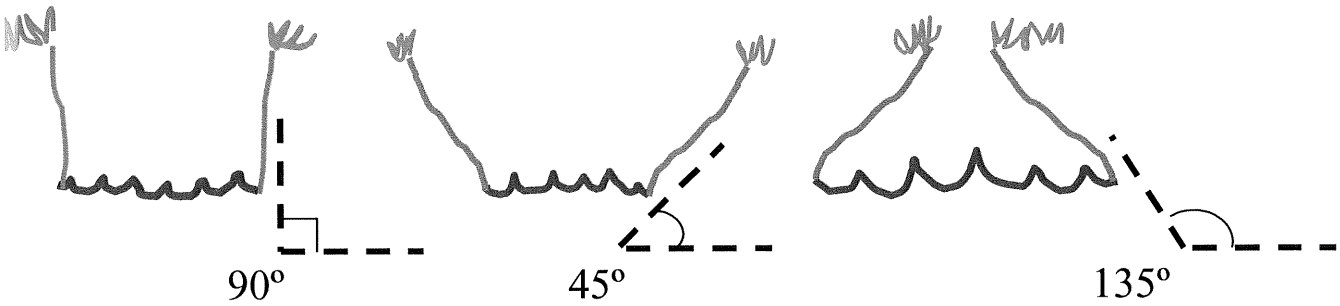
Remarks_____

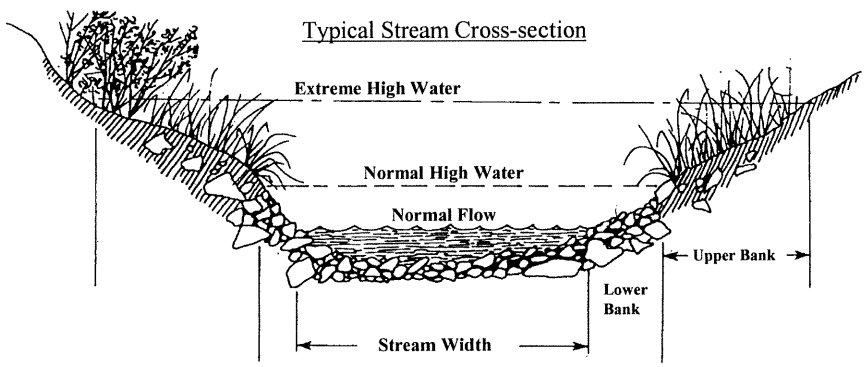
Page Total_____

☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream. **TOTAL SCORE**_____

Supplement for Habitat Assessment Field Data Sheet

Diagram to determine bank angle:





This side is 45° bank angle.

Site Sketch:

Other comments:_____

_____

_____

_____

_____